Assiniboine River; Photo: Paul Mutch

REDBOINE
WATERSHED DISTRICT

2022 regional report

LAKE WINNIPEG
community-based monitoring network

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Lake Winnipeg Community-Based Monitoring Network: Overview

The Lake Winnipeg Community-Based Monitoring Network (LWCBMN), coordinated by the Lake Winnipeg Foundation (LWF), mobilizes citizens and watershed partners to collect water samples across Manitoba in order to measure phosphorus concentration. Phosphorus is the nutrient responsible for blue-green algae blooms on Lake Winnipeg. Phosphorus comes from diverse sources across the watershed, including municipal wastewater and agricultural runoff.

Different sub-watersheds contribute different proportions of Lake Winnipeg's total phosphorus load. With the help of a strong network of watershed partners and citizen scientists, this long-term monitoring program is identifying phosphorus hotspots – localized areas that contribute higher amounts of phosphorus to waterways than other areas. Targeting actions to reduce phosphorus loading in hotspots will reduce the amount of phosphorus entering Manitoba's lakes and rivers, and improve the health of Lake Winnipeg.

Snow melts, floods and heavy rainfall events are responsible for most of the phosphorus that is flushed from the land and carried into our waterways. LWCBMN samples frequently throughout the season, and particularly during the spring melt, to ensure we capture phosphorus runoff during these high-water events.

Most LWCBMN sampling is conducted at stations where water flow is continuously monitored by the Water Survey of Canada (WSC). By tracking flow online using the WSC's real-time data, the network can notify partners and citizen scientists across the watershed to ensure frequent sampling during peak flows.

Sites with flow data can be coupled with LWCBMN data to calculate **phosphorus loads**. We need several samples throughout the season, corresponding to changes in flow, to accurately calculate these loads. Phosphorus loads can subsequently be used to calculate **phosphorus export**, based on the area of the watershed.

Phosphorus load is the total amount of phosphorus flowing past a sample site over a given period of time, expressed as tonnes per year.

Phosphorus export is the amount of phosphorus exported by each hectare of land in a year, expressed as kg/ha/y.

Sample Collection & Site Map

Water samples are collected using a weighted sampling device that collects source water directly into a 500 mL Nalgene polyethylene bottle. The sampling device is lowered into the water just before it hits the bottom, the bottle is filled, then brought back to the surface. It is rinsed three times prior to sample collection. Next, a 60 mL Nalgene polyethylene bottle containing 1 mL 4N H_2SO_4 is filled with whole water from the collection bottle.

In 2022, 1588 unfiltered water samples were collected and analyzed from 110 sites. Of these 110 LWCBMN sampling sites, 92 are located near flow-metered WSC stations, five are located near non-flow-metered WSC stations, and one is located near a USGS station, and twelve are not located near any stations.

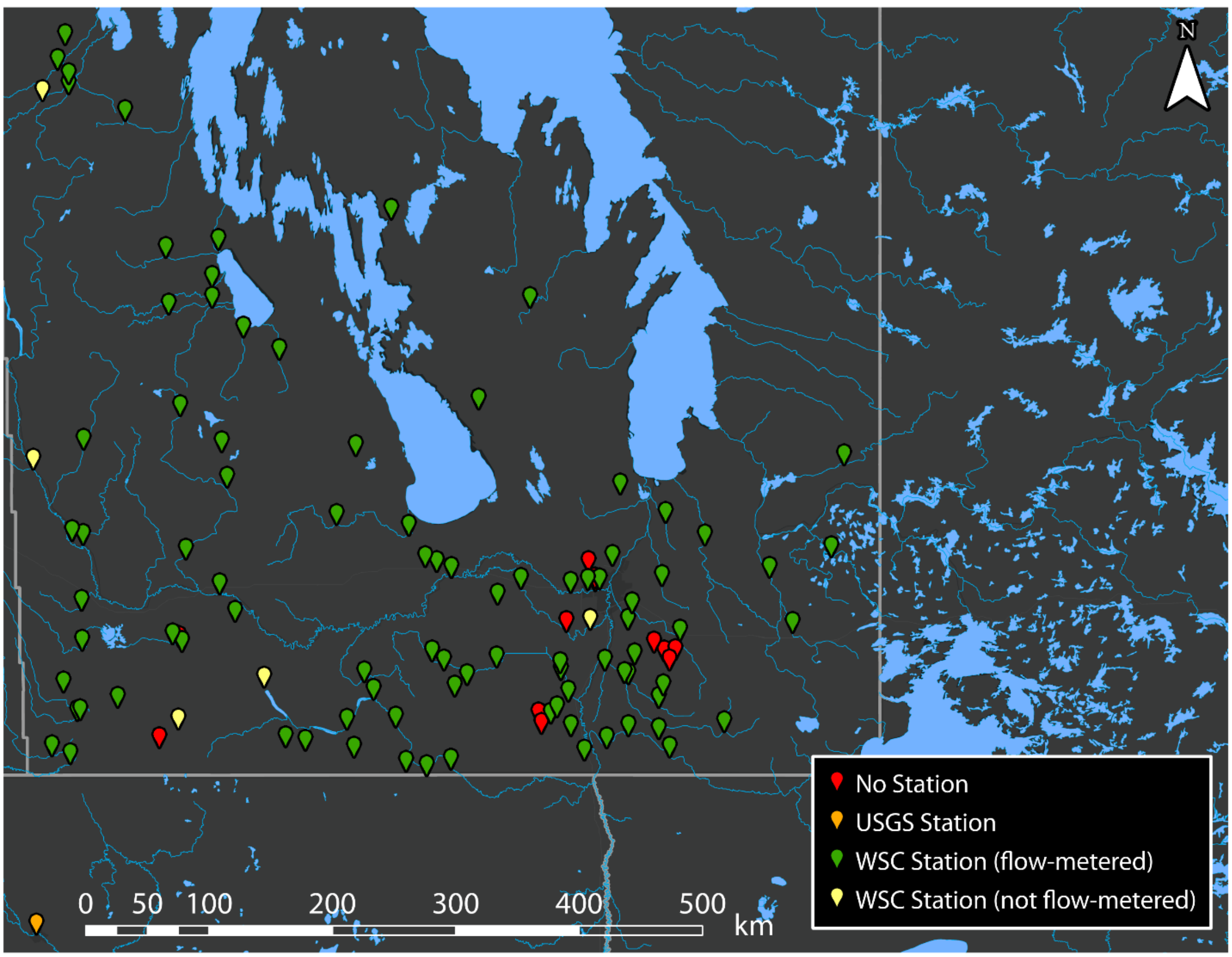


Figure 1: Map of LWCBMN sampling sites in 2022. Locations shown provided at least one sample. Colours indicate nearby station type.

Laboratory & Data Analysis

LWCBMN water samples are analysed for total phosphorus concentration. The analysis of a sample for total phosphorus (TP) is a two-step procedure involving first the chemical digestion/conversion of all P forms to orthophosphate (PO_4^{3-}) followed by the analysis of the concentration of PO_4^{3-}. The digestion procedure is patterned after USGS Water-Resources Investigations Report 03-4174. The concentration of PO_4^{3-} in the sample was determined following Murphy & Riley (1962). The result of this analytical method is determination of unfiltered total phosphorus in mg/L.

Laboratory analysis on LWCBMN water samples was conducted in partnership with Dr. Nora Casson at her laboratory at the University of Winnipeg. Quality assurance of laboratory methods for the determination of total phosphorus was completed on samples sent from Proficiency Testing Canada. Proficiency testing allows us to assess the quality of our results as compared to the results of other laboratories across the country. We received excellent passing grades of 92/100 in November 2023 and 94/100 in May 2024, further highlighting the consistency and accuracy of our laboratory methods.

Our laboratory results provide a record of the phosphorus concentrations for every day that water samples were collected, but we are equally interested in reporting the actual load of phosphorus each year in each watershed that we sample. To create this record, we multiply concentrations by the volume of water that flowed past the station every day. The Water Survey of Canada (WSC) records daily flows at most of our stations. For each station, gaps between concentration observations are filled by linear interpolation to create a continuous daily record. For the WSC flow record before or after the first or last water sample collected, we estimate the missing daily mean concentrations to be equal to the first or last measured concentration, respectively. These measured and estimated daily concentrations are then multiplied by daily flow to create a record of daily phosphorus loads.

Larger watersheds generate greater river flow and typically larger phosphorus loads. Comparing the intensity of phosphorus sources, especially among watersheds of varying sizes, is possible through the calculation of average load exported from each unit area of the watershed. Hence, we also report phosphorus export, which is simply the annual load divided by the watershed area that contributed to this load.

The export per unit area is indicative of the relative intensity of the sources generating phosphorus export, even among watersheds of different sizes. This is why we display maps of phosphorus export (and not load) in this report. Hotspots identified in these reports export several times more phosphorus per hectare than non-hotspot watersheds. Identifying hotspots can help government agencies to focus phosphorus reduction programs efficiently throughout the Province.

LWCBMN By the Numbers - 2022

Table 1: Summary of 2022 LWCBMN sampling activity by region.

Region	Number of sites	Number of samples	Site with highest regional total phosphorus (TP) export (kg/ha/y)	Mean % of spring* water load	Mean % of spring* TP load
Assiniboine West	10	170	Little Saskatchewan River near Minnedosa (0.44)	58.63	60.54
Central Assiniboine	2	48	Cypress River near Bruxelles (1.37)	87.85	80.32
City of Winnipeg	5	103	Omand's Creek near Empress Street (1.45)	87.84	91.60
East Interlake	3	24	Netley Creek near Petersfield (0.91)	67.88	81.05
Inter-Mountain	7	110	Ochre River near Ochre River (2.72)	66.73	77.45
Northeast Red	4	34	Devil's Creek near Libau (1.31)	63.71	68.56
Pembina Valley	16	216	Rivière aux Marais near Christie (3.22)	80.87	83.45
Redboine	15	195	South Tobacco Creek near Miami (3.99)	80.86	84.10
Souris River	13	122	Elgin Creek near Souris (0.26)	63.41	54.70
Seine Rat Roseau	19	333	Joubert Creek at St-Pierre-Jolys (2.74)	70.73	74.38
Swan Lake	6	90	Birch River near Birch River (0.83)	79.69	92.88
West Interlake	2	39	Burnt Lake Drain Northwest of Lundar (0.077)	19.56	17.44
Whitemud	4	54	Big Grass River near Glenella (0.78)	59.70	56.13
Winnipeg River	4	50	Bird River outlet of Bird Lake (0.20)	47.54	48.72

*LWCBMN defines "Spring" as March 1 to May 31, inclusive.

Raw data (phosphorus concentration and water flow) from LWCBMN's 2020 field season is available online at LakeWinnipegDataStream.ca, an open access hub for sharing water data.

Redboine Watershed District

The Redboine Watershed District (RWD) is located west of the City of Winnipeg. RWD consists of two major watersheds: The La Salle and Boyne-Morris River watersheds. The primary land use in RWD is agriculture, specifically annual crops and livestock. RWD comprises many large and small municipalities that pose a potential risk for phosphorus contribution through discharge of wastewater lagoons, sewage treatment plants and urban runoff. Major towns include Elie, Carman and Holland. In 2020, RWD boundaries expanded to include all of the Boyne River and Shannon Creek watersheds.

In partnership with LWCBMN, RWD staff, volunteers, and partners from Deerwood Soil and Water Management Association Center sampled 15 sites in RWD all of which were located near actively monitored WSC flow meters.

RWD Website (redboine.ca)

RWD Watershed Plans (redboine.ca/iwmp)

Characteristics of the 2022 Field Season

The 2022 field season was historically wet. The winter of 2021-2022 provided most of southern Manitoba with 150+ cm of snow, the third highest amount of snowfall since 1872. Additionally, record precipitation in April and May saw large amounts of rain and snow falling on mostly frozen, impermeable soils. Specifically, in the month of April, southern Manitoba and the US portion of the Red River watershed received 400-600% of their normal precipitation (120-160 mm). Flooding was a huge issue across the southern part of the province, where almost all LWCBMN sites are located. The mean peak discharge date across all LWCBMN sites with analyzed water samples was May 10, 2022 (with a standard deviation of 19 days). In 2022, an average of 65.83% of stream discharge occurred in the spring (March 1 – May 31) across LWCBMN sites (with a standard deviation of 21.10%). During the period of extreme flooding, safety concerns prevented sampling from occurring at some sites. As a result, some load/export calculations may be less accurate than they would be had sampling remaining frequent during these times.

Manitoba Watershed District Map

Manitoba's watershed districts are crucial partners contributing to the success of LWCBMN. In addition to assisting with sample collection, each district brings valuable community connections and a wealth of regional expertise to the network, helping us contextualize and better understand the data.

In 2022, 12 watershed districts participated in LWCBMN activities: Assiniboine West, Central Assiniboine, East Interlake; Inter-Mountain; Northeast Red, Pembina Valley, Redboine, Souris River, Seine Rat Roseau, Swan Lake, West Interlake, and Whitemud.

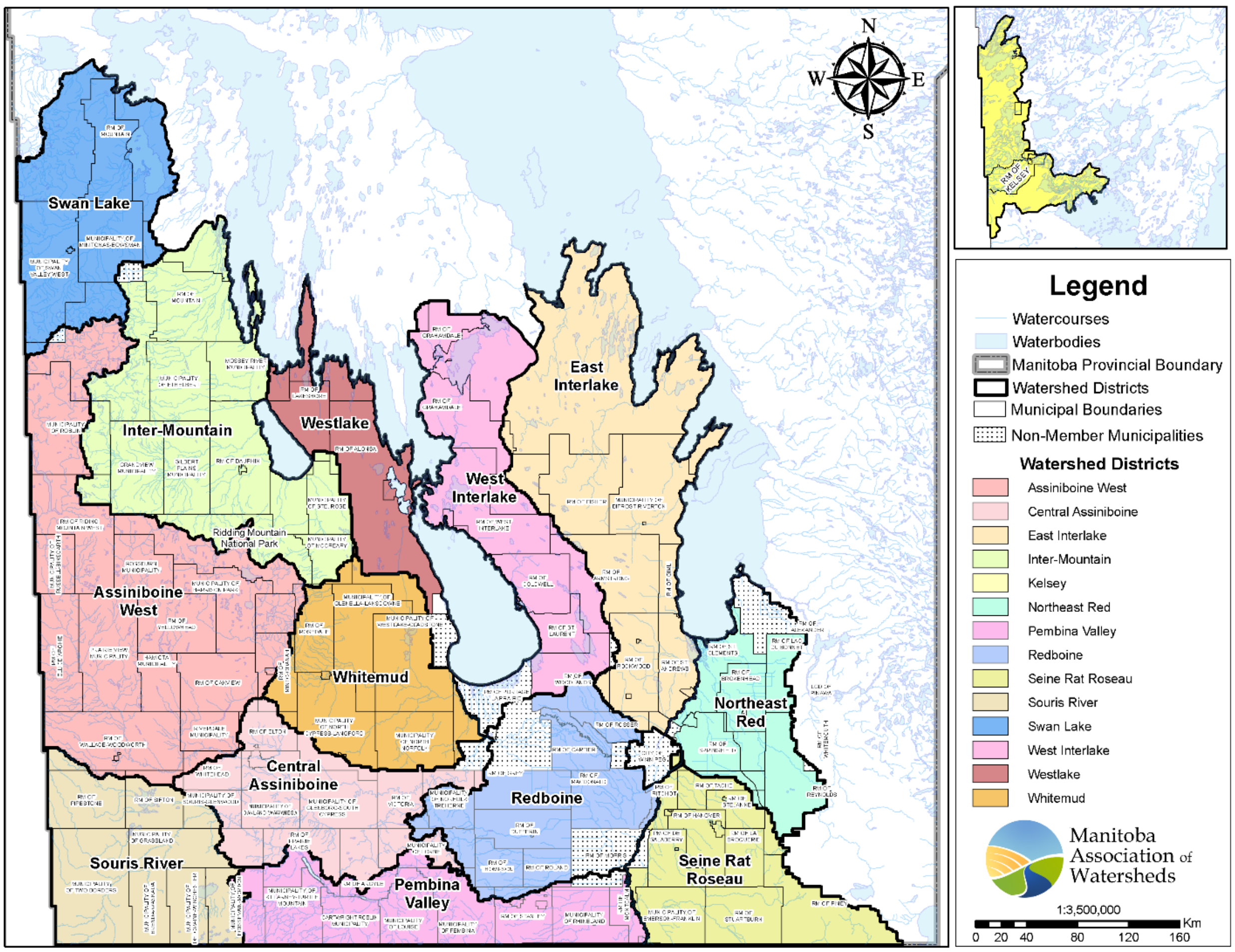


Figure 2: Manitoba Watershed District Boundaries. There are 14 total watershed districts. Map provided by Manitoba Association of Watersheds (updated July 2022).

2022 Results – Redboine Summary

Table 2: Summary of 2022 LWCBMN results in Redboine. Letters correspond to drainage areas in Figure 3. Data shown represents sites with sampling efforts adequate enough to calculate loads/exports. [1]See footnote for explanation of acronyms/abbreviations.

	Site Name	WSC Station	GDA (km^2)	IDA (km^2)	Gross/ Incr.	TP load (tonnes/y)	TP export (kg/ha/y)
A	Assiniboine River near Headingly	05MJ001	161455	11052.37	Incr.	847.86	0.77
B	Boyne River near Carman	05OF003	1134.51	322.23	Incr.	-16.29	-0.51
C	Boyne River near Roseisle	05OF011	594.16	*NA*	gross	29.70	0.50
D	Elm Creek Channel near Elm Creek	05OG005	594.52	*NA*	gross	41.84	0.70
E	La Salle River at Elie	05OG008	195.1	*NA*	gross	50.61	2.60
F	Little Morris River near Rosenort	05OF024	986.24	780.44	Incr.	30.11	0.39
G	Morris River near Rosenort	05OF020	2224.14	1089.63	Incr.	26.12	0.24
H	Roseisle Creek near Roseisle	05OF009	218.12	*NA*	gross	38.82	1.80
I	Shannon Creek near Morris	05OF014	635.58	*NA*	gross	58.62	0.92
J	South Tobacco Creek near Miami	05OF017	75.92	*NA*	gross	30.29	3.99
K	Tobacco Creek near Rosebank	05OF018	129.87	*NA*	gross	20.06	1.54

To compare 2022 results to other years of data, please see LWCBMN regional reports online at https://lakewinnipegfoundation.org/lwcbmn-regional-reports

[1] WSC = Water Survey of Canada.
GDA = gross drainage area (i.e., the total watershed area).
IDA = incremental drainage area (i.e., the total watershed area minus the total watershed area of any contained upstream sites with data adequate for load/export calculation).
Gross/Incr. = whether or not the adjacent TP load/export listed is from the gross or incremental ("Incr.") drainage area of a site.

2022 Results – Hotspot Map

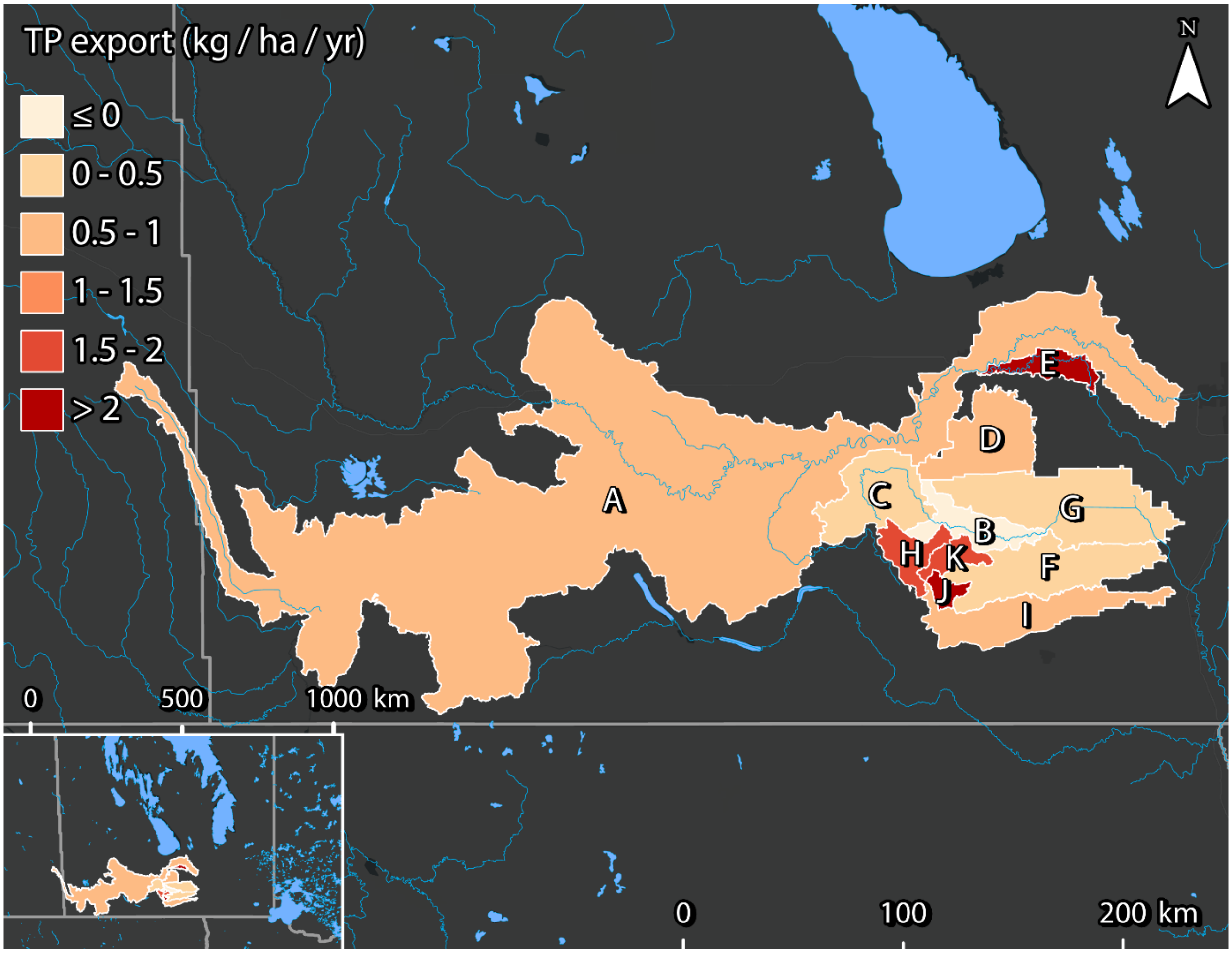


Figure 3: 2022 LWCBMN TP Export Hotspots in Redboine. Letters correspond to sites listed in Table 2.

2022 Results – Individual Sites

La Salle River at Elie

The upstream reach of the La Salle River is located east of Portage la Prairie and runs easterly. The drainage area contains primarily agricultural land, including both cropland and livestock. This sampling site is located at Water Survey of Canada flow meter 05OG008. The sampling effort provided adequate coverage to calculate TP loads and exports.

Table 3: Indices of discharge and phosphorus from the gross drainage area of La Salle River at Elie (05OG008) in 2022.

Gross drainage area:	195.1 km^2
Peak discharge:	19.73 $m^3\ s^{-1}$ (2022-05-01)
Peak TP concentration:	2.00 mg/L (2022-09-20)
% of water load in spring:	78.36%
% of TP load in spring:	77.10%
Water load:	0.047 $km^3\ y^{-1}$
TP load:	50.61 tonnes P y^{-1}
Water export:	239.05 mm y^{-1}
TP export:	2.59 kg P $ha^{-1}\ y^{-1}$

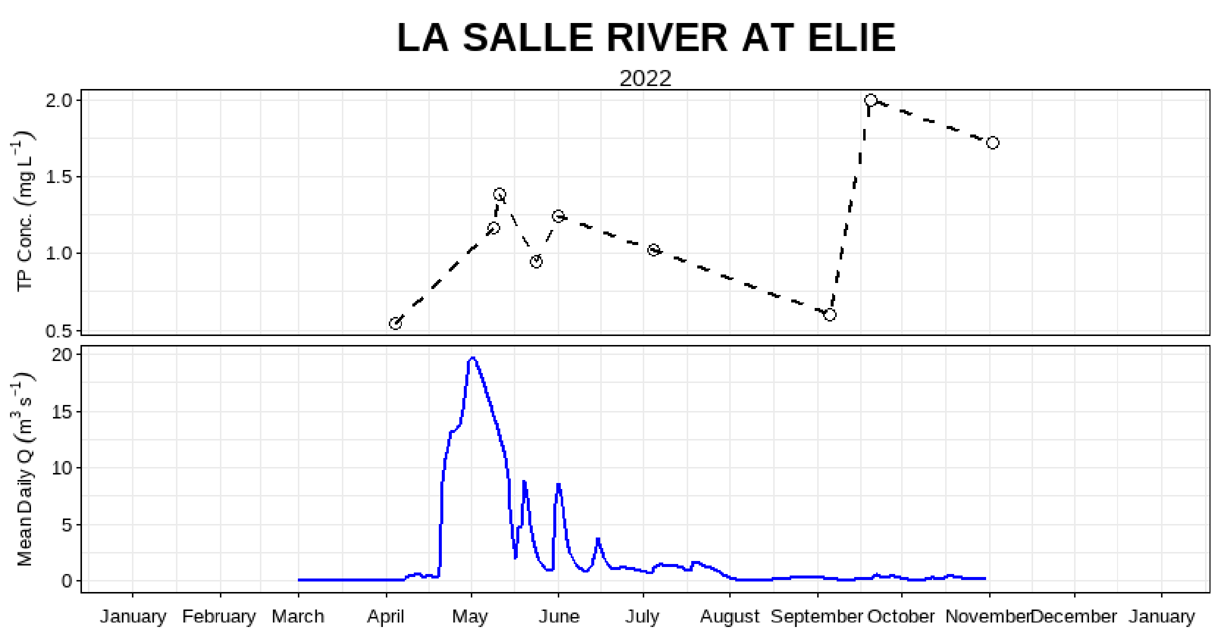


Figure 4: Mean daily discharge ($m^3\ s^{-1}$) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at La Salle River at Elie (05OG008).

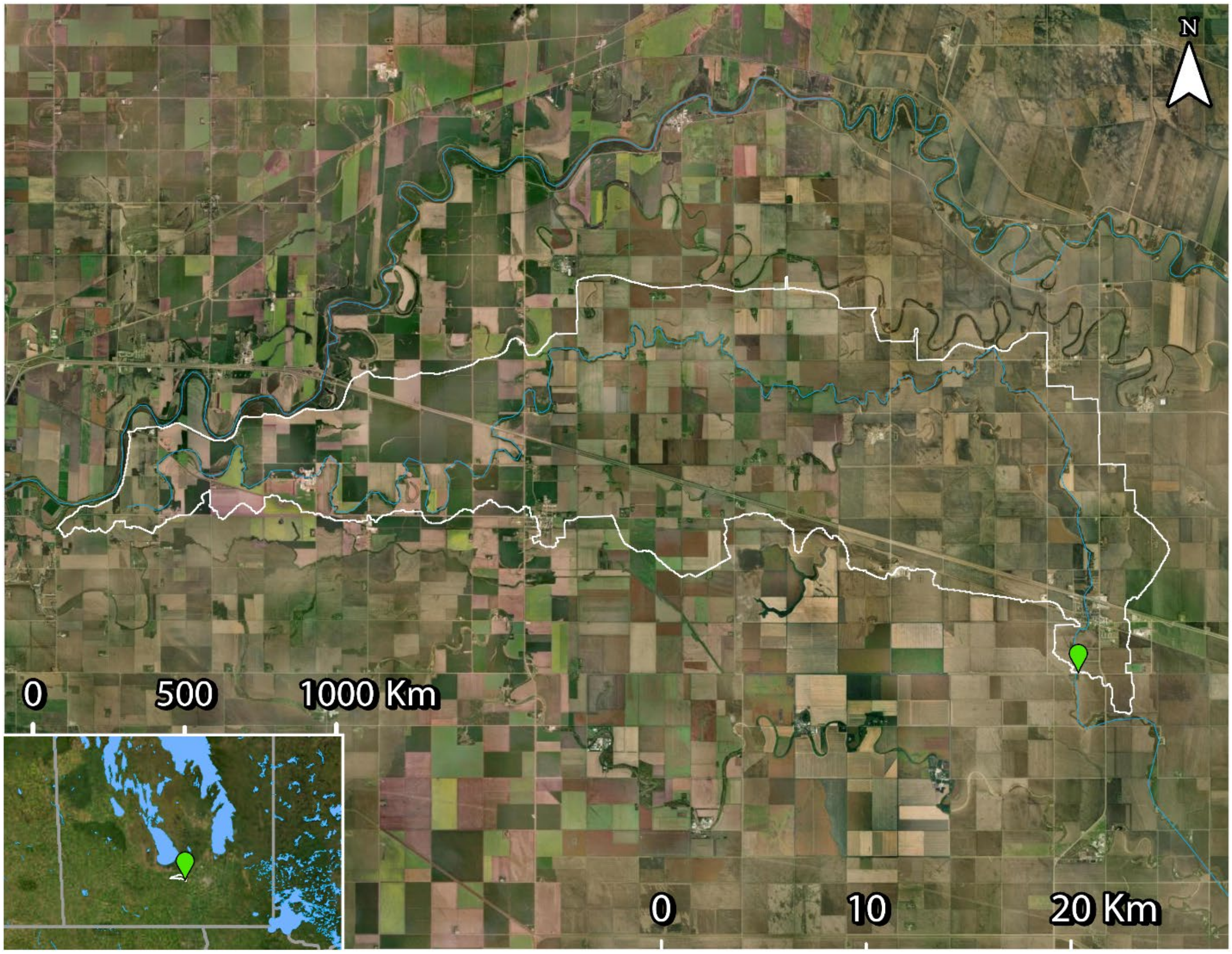


Figure 5: WSC station 05OG008 (green) and drainage area polygon (white - source: WSC). LWCBMN samples directly at the WSC station.

Elm Creek Channel near Elm Creek

Elm Creek Channel is situated south-east of Portage La Prairie, MB. and flows easterly towards the La Salle River. The drainage area for this sampling site includes a largely agricultural area and the community of Saint Claude, MB. Cropland is limited in this drainage area relative to others in the La Salle watershed; however, there are slightly more livestock. This sampling site is located at Water Survey of Canada station 05OG005, north of Elm Creek, MB. The sampling effort provided adequate coverage to calculate TP loads and exports.

Table 4: Indices of discharge and phosphorus from the gross drainage area of Elm Creek Channel near Elm Creek (05OG005) in 2022.

Gross drainage area:	594.52 km^2
Peak discharge:	38.68 $m^3\ s^{-1}$ (2022-05-01)
Peak TP concentration:	1.02 mg/L (2022-04-21)
% of water load in spring:	79.72%
% of TP load in spring:	88.07%
Water load:	0.070 $km^3\ y^{-1}$
TP load:	41.84 tonnes P y^{-1}
Water export:	118.12 mm y^{-1}
TP export:	0.70 kg P $ha^{-1}\ y^{-1}$

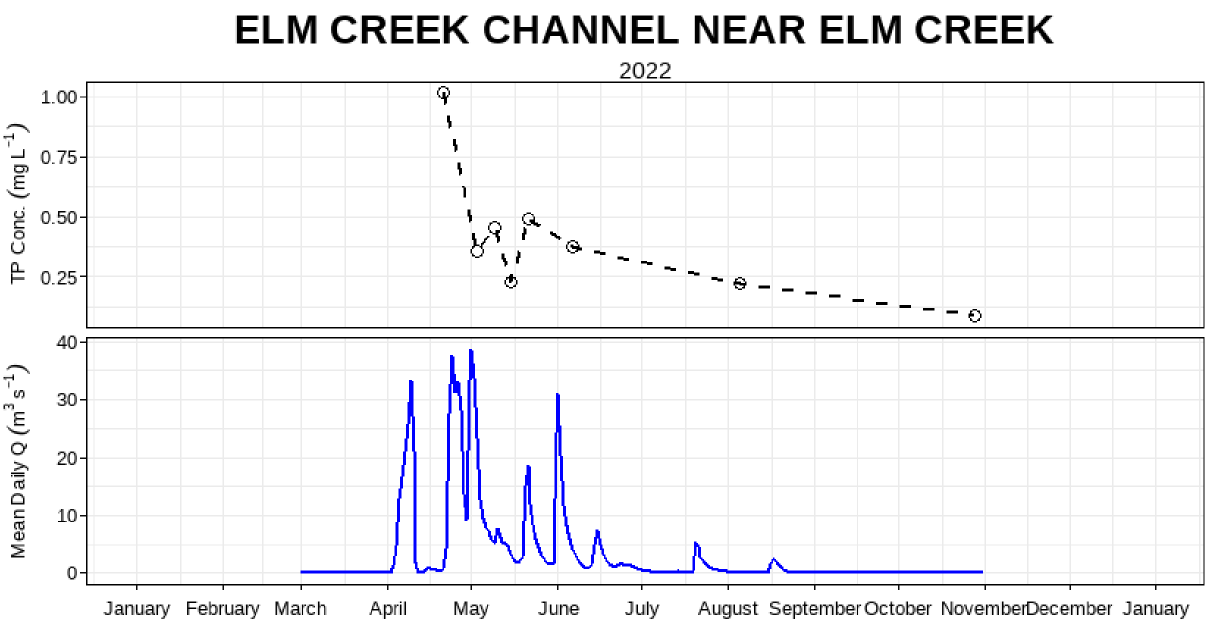


Figure 6: Mean daily discharge ($m^3\ s^{-1}$) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at Elm Creek Channel near Elm Creek (05OG005).

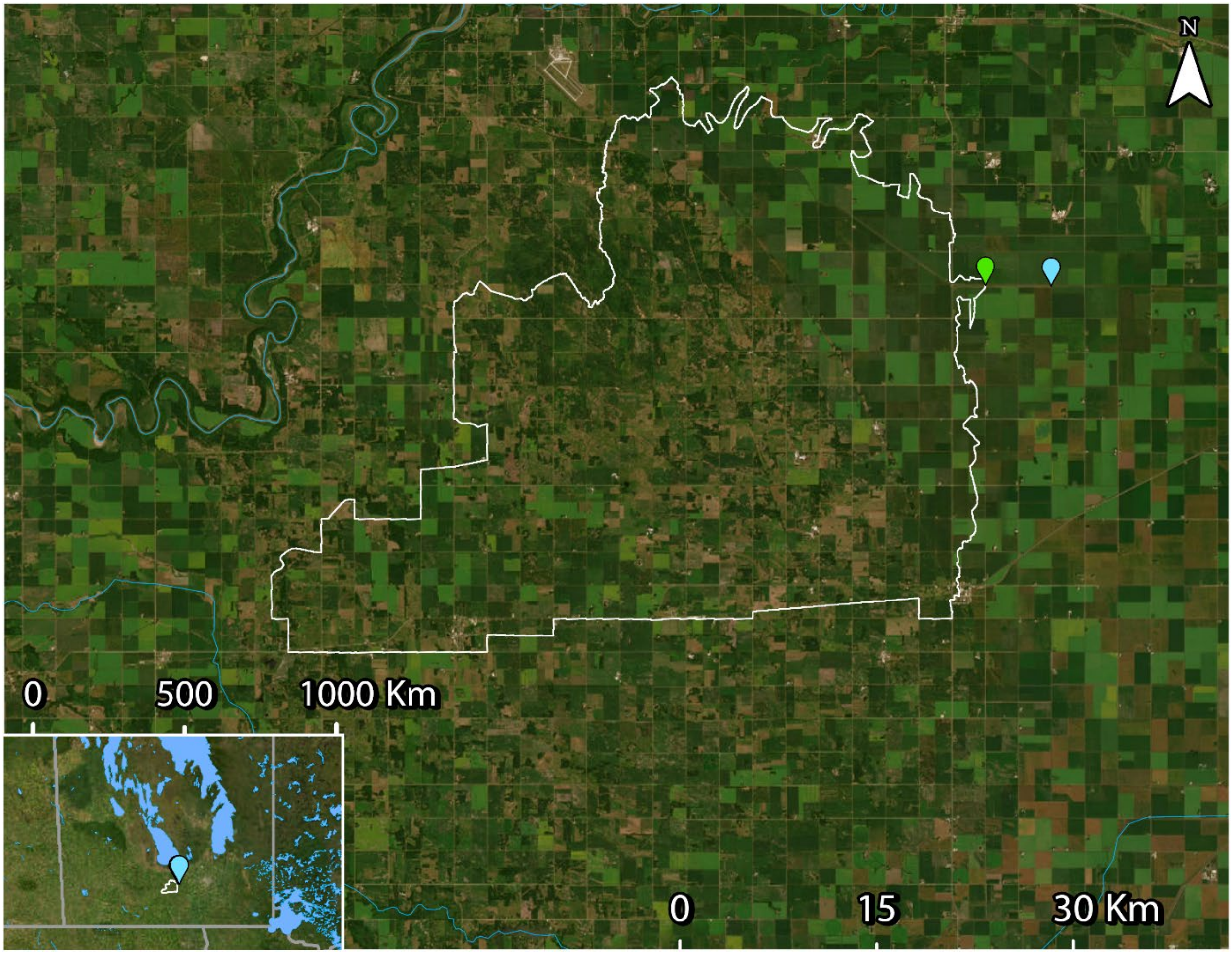


Figure 7: WSC station 05OG005 (green), LWCBMN sampling site (blue), and drainage area polygon (white - source: WSC). LWCBMN sampling about 3km east of the WSC station for safety reasons. The bridge which used to be located next to the WSC station is no longer there. Although there is distance between the WSC station and the sampling site, between the two points it is a very straight and consistent channel with no additional tributaries.

Boyne River near Carman

This downstream reach of the Boyne River begins directly upstream of Stephenfield Lake and flows to Carman, Man. The incremental drainage area for this sampling site includes a largely agricultural area. This sampling site is located at Water Survey of Canada station 05OF003, near Carman, MB. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 5: Indices of discharge and phosphorus from the incremental drainage area of Boyne River near Carman (05OF003). See Supplemental Table 1 for gross calculations.

Incremental drainage area:	322.23 km^2
Peak discharge:	154.99 $m^3\ s^{-1}$ (2022-05-04)
Peak TP concentration:	0.70 mg/L (2022-04-11)
% of water load in spring:	75.68%
% of TP load in spring:	80.94%
[1]Incremental water load:	-0.030 $km^3\ y^{-1}$
[1]Incremental TP load:	-16.29 tonnes P y^{-1}
[2]Incremental water export:	-93.75 mm y^{-1}
[2]Incremental TP export:	-0.51 kg P $ha^{-1}\ y^{-1}$

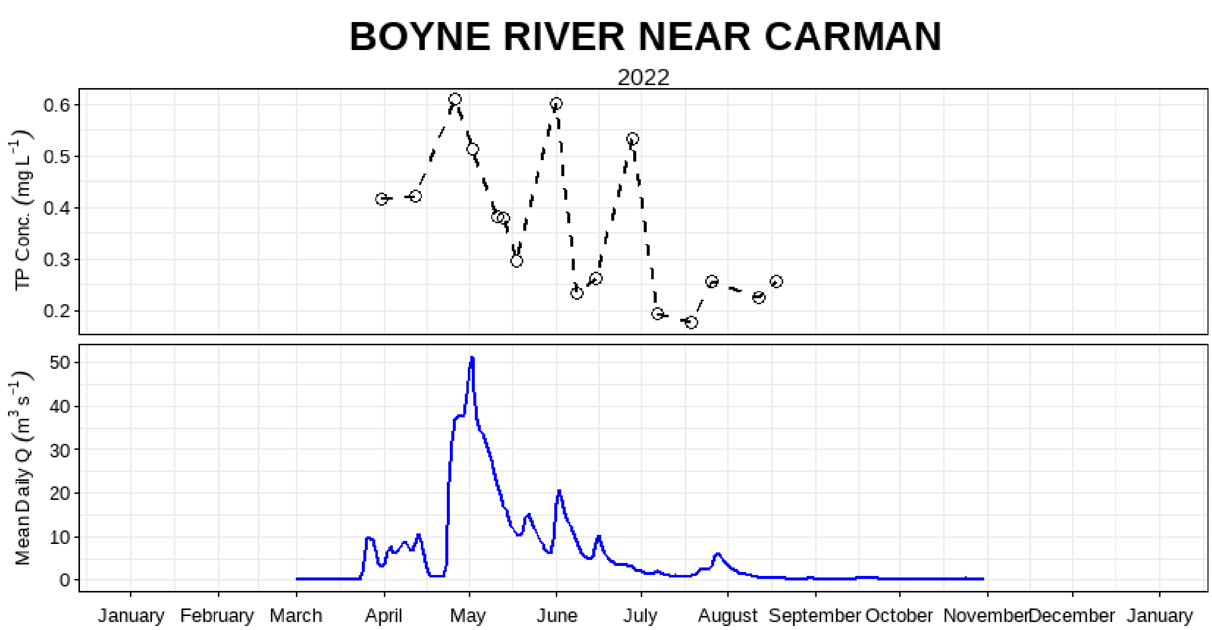


Figure 8: Mean daily discharge ($m^3\ s^{-1}$) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at Boyne River near Carman (05OF003).

[1] Incremental loads are calculated by subtracting gross "Boyne River near Roseisle" and "Roseisle Creek near Roseisle" from "Boyne River near Carman" values.

[2] Incremental exports are calculated by dividing incremental loads by incremental drainage areas.

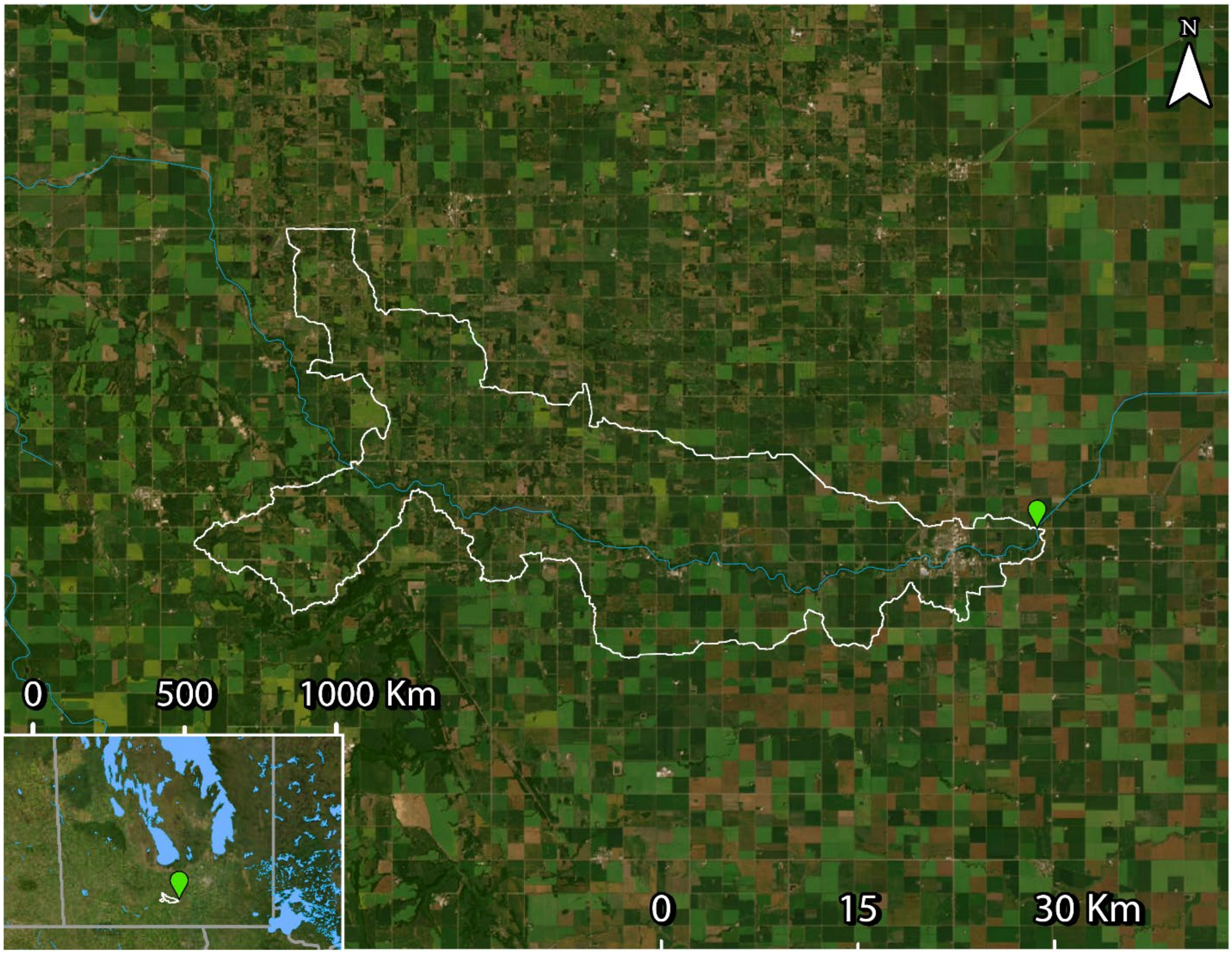


Figure 9: WSC station 05OF003 (green), and incremental drainage area polygon (white - source: WSC). See Supplemental Figure 1 for upstream drainage areas used to calculate incremental area. LWCBMN samples directly at the WSC station.

Boyne River near Roseisle

This upstream reach of the Boyne River begins near Holland, MB, and flows into Stephenfield Lake. The drainage area for this sampling site includes the towns of Holland, Treherne and Rathwell, MB, as well as a mixture of crop land and forested areas. This sampling site is located at Water Survey of Canada flow meter 05OF011, near Roseisle, MB. The sampling effort provided adequate coverage to calculate TP loads and exports.

Table 6: Indices of discharge and phosphorus from the gross drainage area of Boyne River near Roseisle (05OF011) in 2022.

Gross drainage area:	594.16 km^2
Peak discharge:	57.01 $m^3\ s^{-1}$ (2022-05-01)
Peak TP concentration:	0.52 mg/L (2022-07-24)
% of water load in spring:	81.80%
% of TP load in spring:	78.03%
Water load:	0.11 $km^3\ y^{-1}$
TP load:	29.70 tonnes P y^{-1}
Water export:	179.42 mm y^{-1}
TP export:	0.50 kg P $ha^{-1}\ y^{-1}$

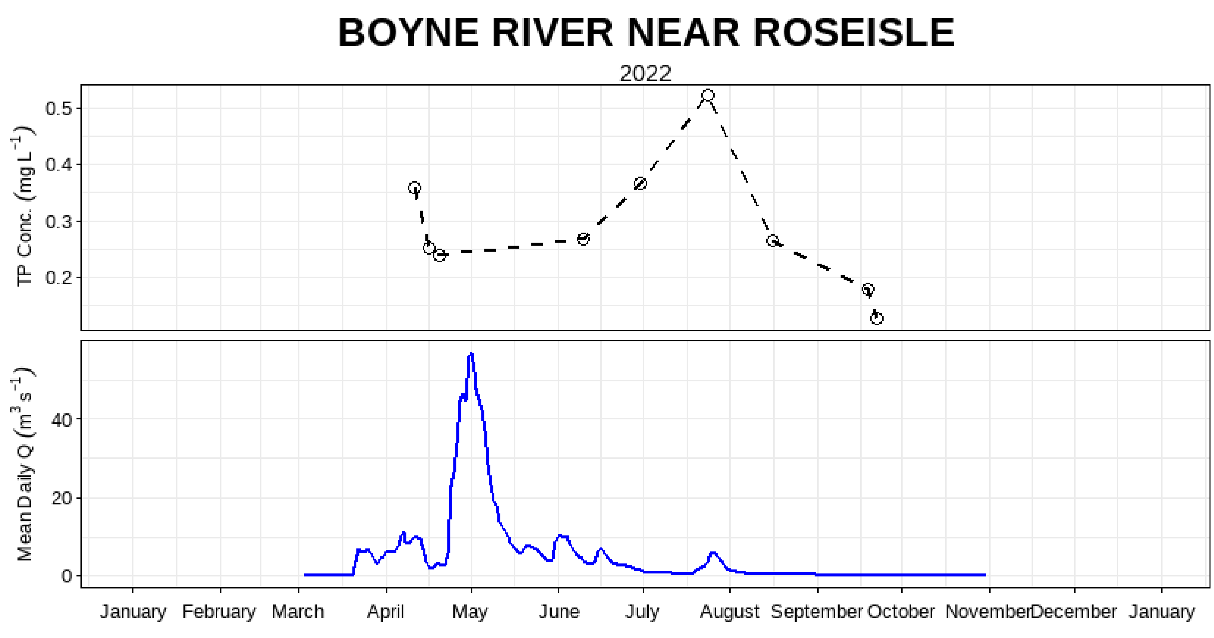


Figure 10: Mean daily discharge ($m^3\ s^{-1}$) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at Boyne River near Roseisle (05OF011).

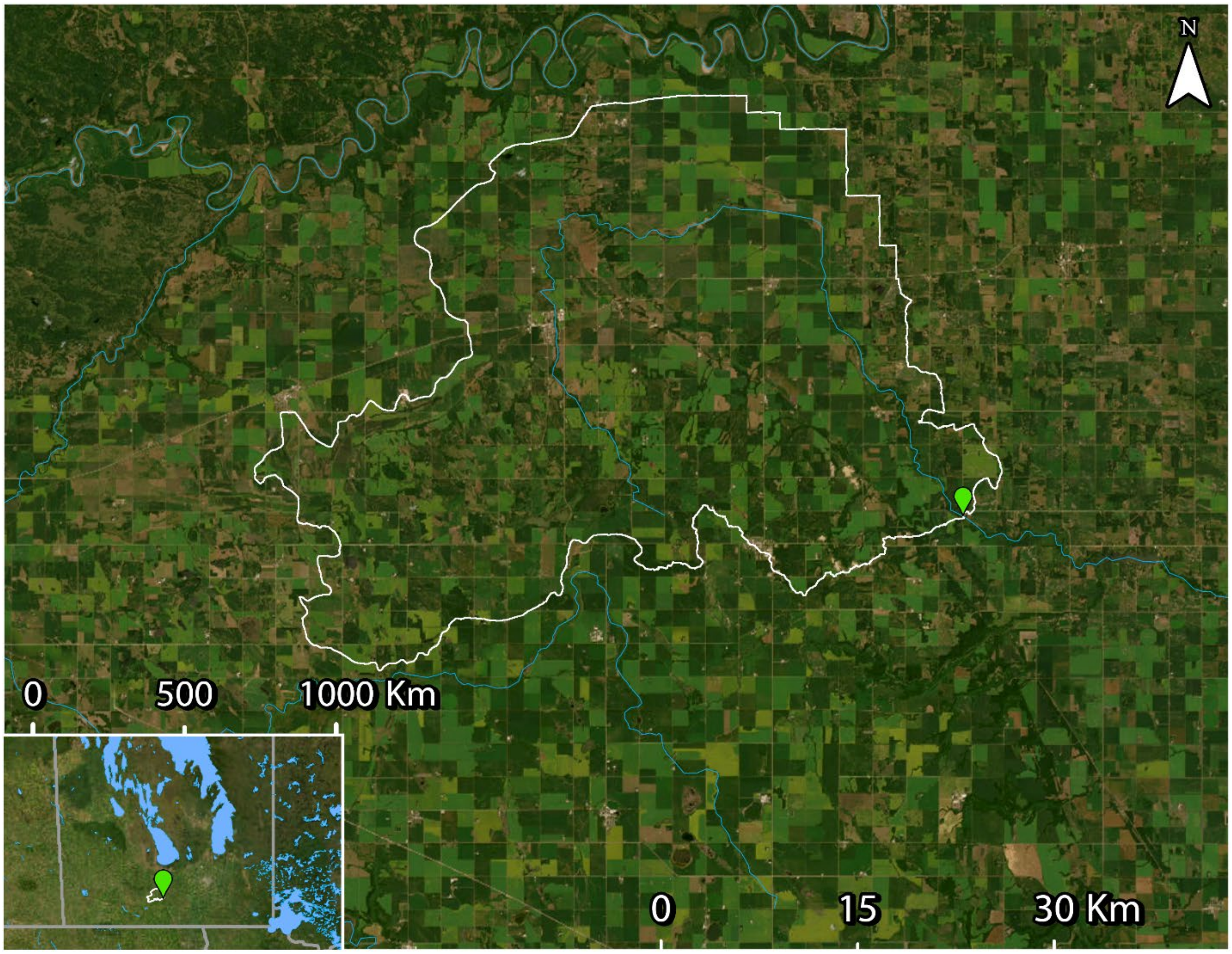


Figure 11: WSC station 05OF011 (green) and drainage area polygon (white – source: WSC). LWCBMN samples directly at the WSC station.

Roseisle Creek near Roseisle

Roseisle Creek flows easterly towards the Boyne River, where the two waterways join slightly upstream of Stephenfield Lake. The drainage area for this sampling site includes a mixture of agricultural cropland and forested areas, as well as the town of Roseisle, MB. This sampling site is located at Water Survey of Canada station 05OF009, near Roseisle, MB. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 7: Indices of discharge and phosphorus from the gross drainage area of Roseisle Creek near Roseisle (05OF009) in 2022.

Gross drainage area:	218.12 km^2
Peak discharge:	30.79 $m^3\ s^{-1}$ (2022-04-30)
Peak TP concentration:	1.75 mg/L (2022-05-31)
% of water load in spring:	89.25%
% of TP load in spring:	90.28%
Water load:	0.042 $km^3\ y^{-1}$
TP load:	38.82 tonnes P y^{-1}
Water export:	193.01 mm y^{-1}
TP export:	1.78 kg P $ha^{-1}\ y^{-1}$

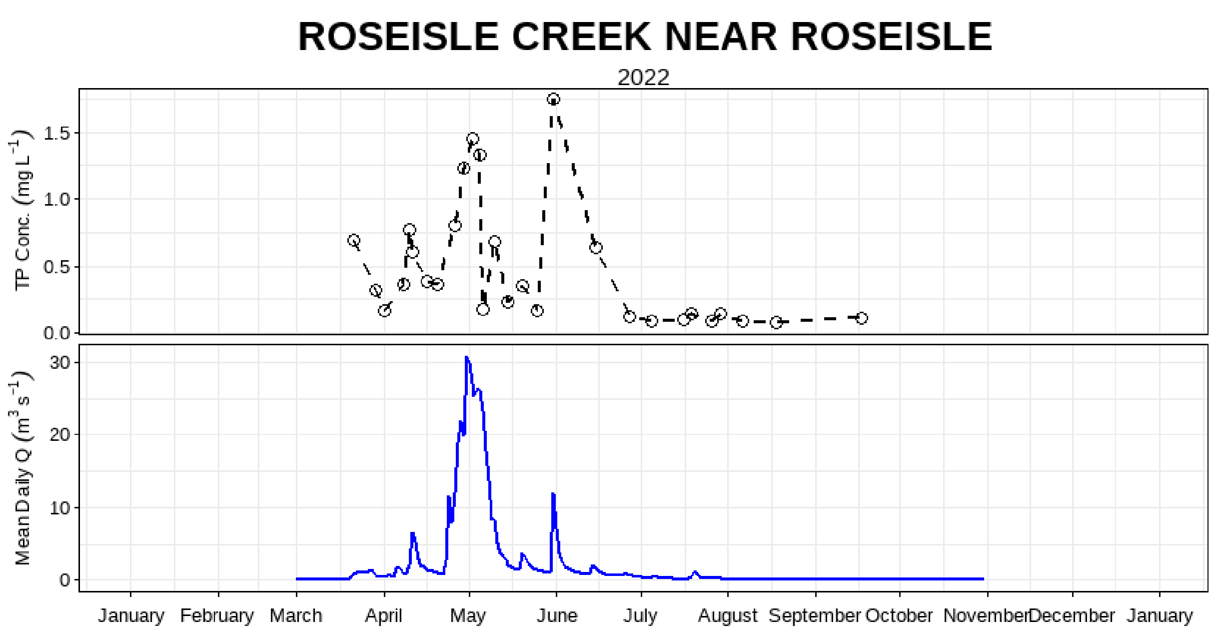


Figure 12: Mean daily discharge ($m^3\ s^{-1}$) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at Roseisle Creek near Roseisle (05OF009).

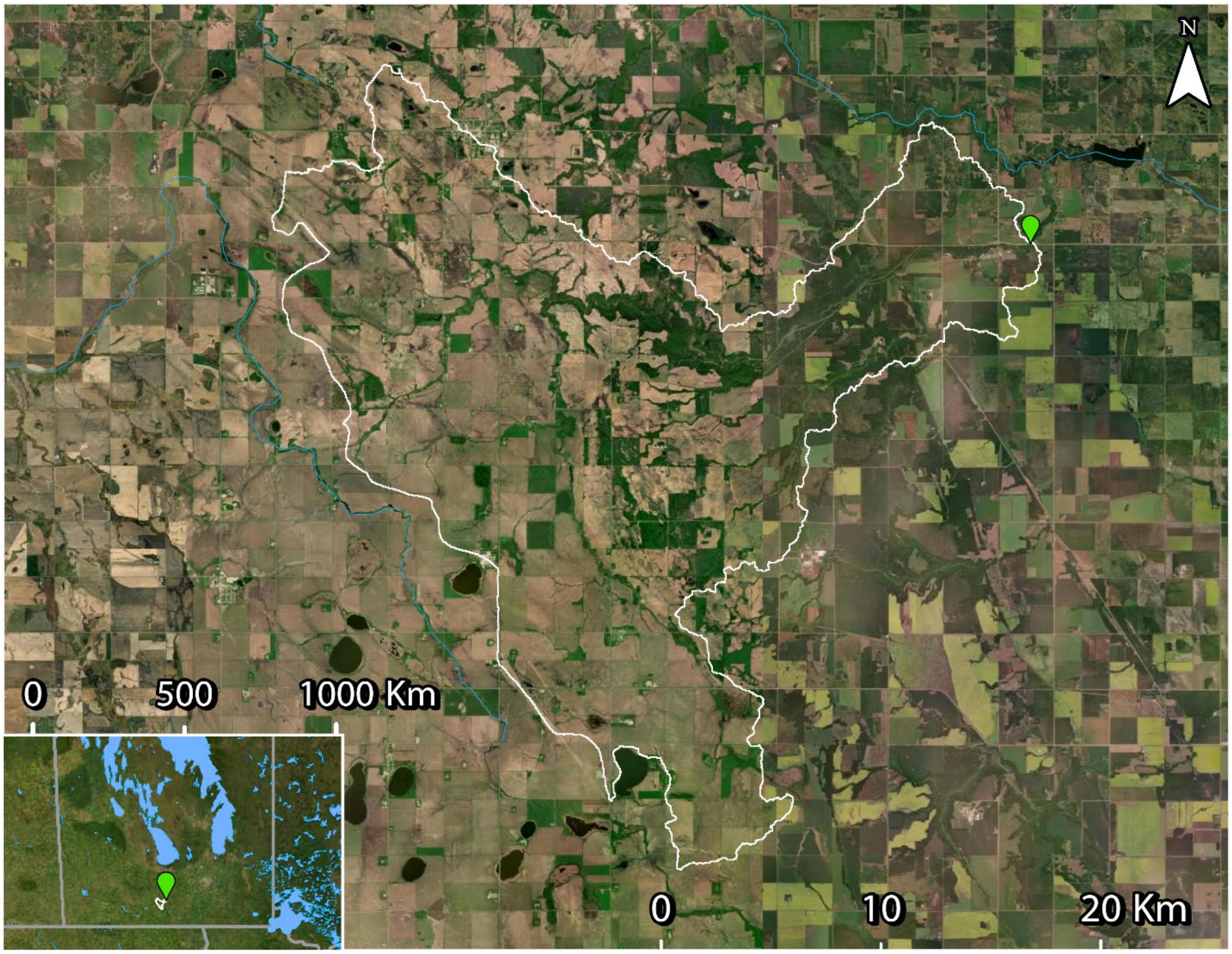


Figure 13: WSC station 05OF009 (green) and drainage area polygon (white – source: WSC). LWCBMN samples directly at the WSC station.

South Tobacco Creek near Miami

South Tobacco Creek flows east into Tobacco Creek. Tobacco Creek flows into the Red River. This sampling site is located at Water Survey of Canada station 05OF017, near Miami, MB. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 8: Indices of discharge and phosphorus from the gross drainage area of South Tobacco Creek near Miami (05OF017) in 2022.

Gross drainage area:	75.92 km^2
Peak discharge:	22.11 $m^3\ s^{-1}$ (2022-04-30)
Peak TP concentration:	4.10 mg/L (2022-04-27)
% of water load in spring:	95.17%
% of TP load in spring:	99.09%
Water load:	0.015 $km^3\ y^{-1}$
TP load:	30.29 tonnes P y^{-1}
Water export:	191.81 mm y^{-1}
TP export:	3.99 kg P $ha^{-1}\ y^{-1}$

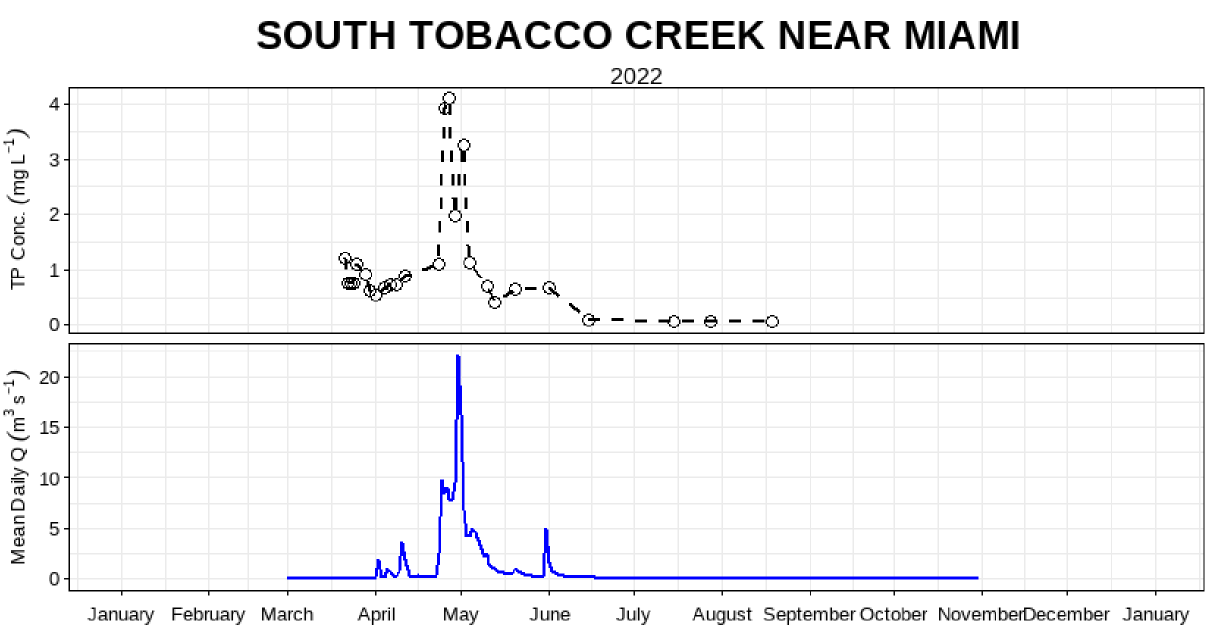


Figure 14: Mean daily discharge ($m^3\ s^{-1}$) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at South Tobacco Creek near Miami (05OF017).

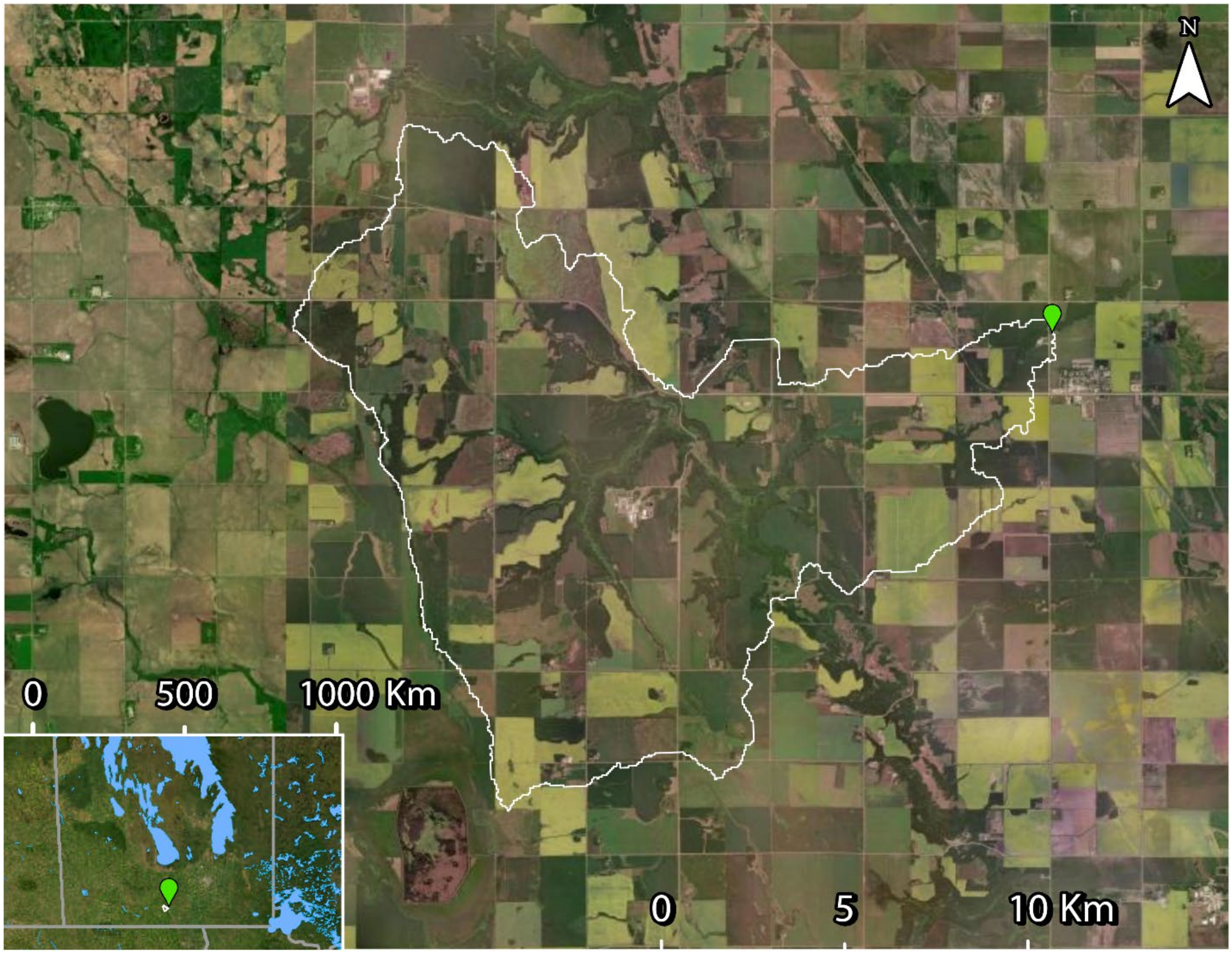


Figure 15: WSC station 05OF017 (green) and drainage area polygon (white – source: WSC). LWCBMN samples directly at the WSC station.

Tobacco Creek near Rosebank

Tobacco Creek is situated northeast of Miami, MB. and flows into the Red River. This sampling site is located at Water Survey of Canada flow meter 05OF018, near Rosebank, MB. The sampling effort provided adequate coverage to calculate TP loads and exports.

Table 9: Indices of discharge and phosphorus from the gross drainage area of Tobacco Creek near Rosebank (05OF018) in 2022.

Gross drainage area:	129.87 km^2
Peak discharge:	33.84 $m^3 s^{-1}$ (2022-05-01)
Peak TP concentration:	1.28 mg/L (2022-05-02)
% of water load in spring:	95.91%
% of TP load in spring:	97.62%
Water load:	0.026 $km^3 y^{-1}$
TP load:	20.06 tonnes P y^{-1}
Water export:	200.27 mm y^{-1}
TP export:	1.54 kg P $ha^{-1} y^{-1}$

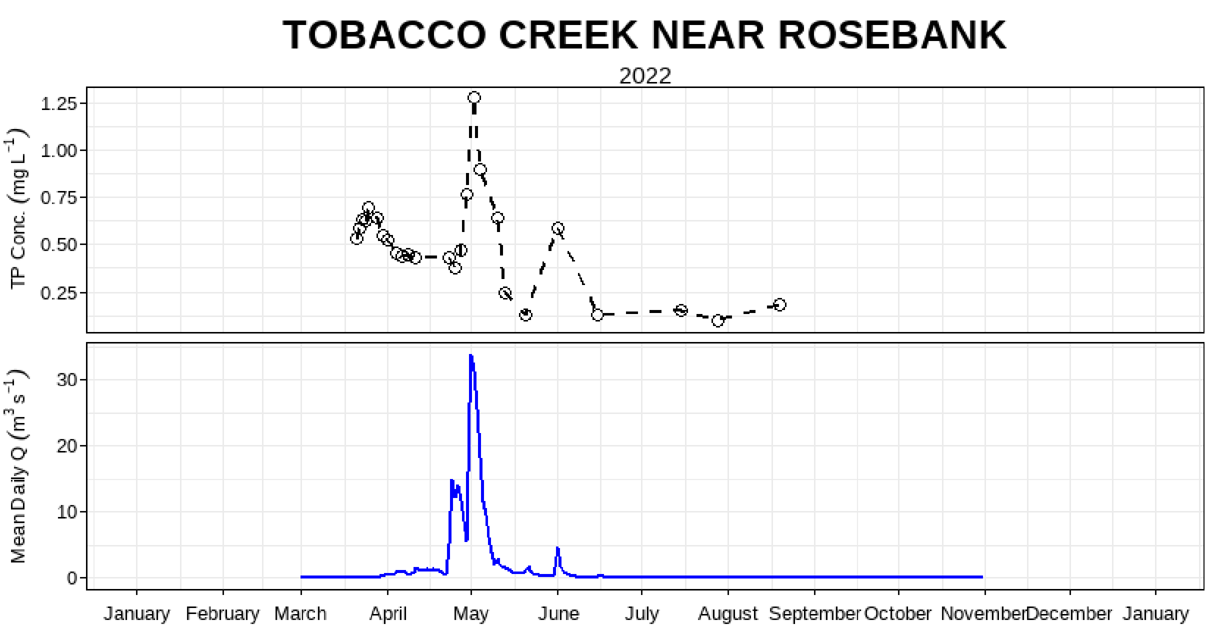


Figure 16: Mean daily discharge ($m^3 s^{-1}$) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at Tobacco Creek near Rosebank (05OF018).

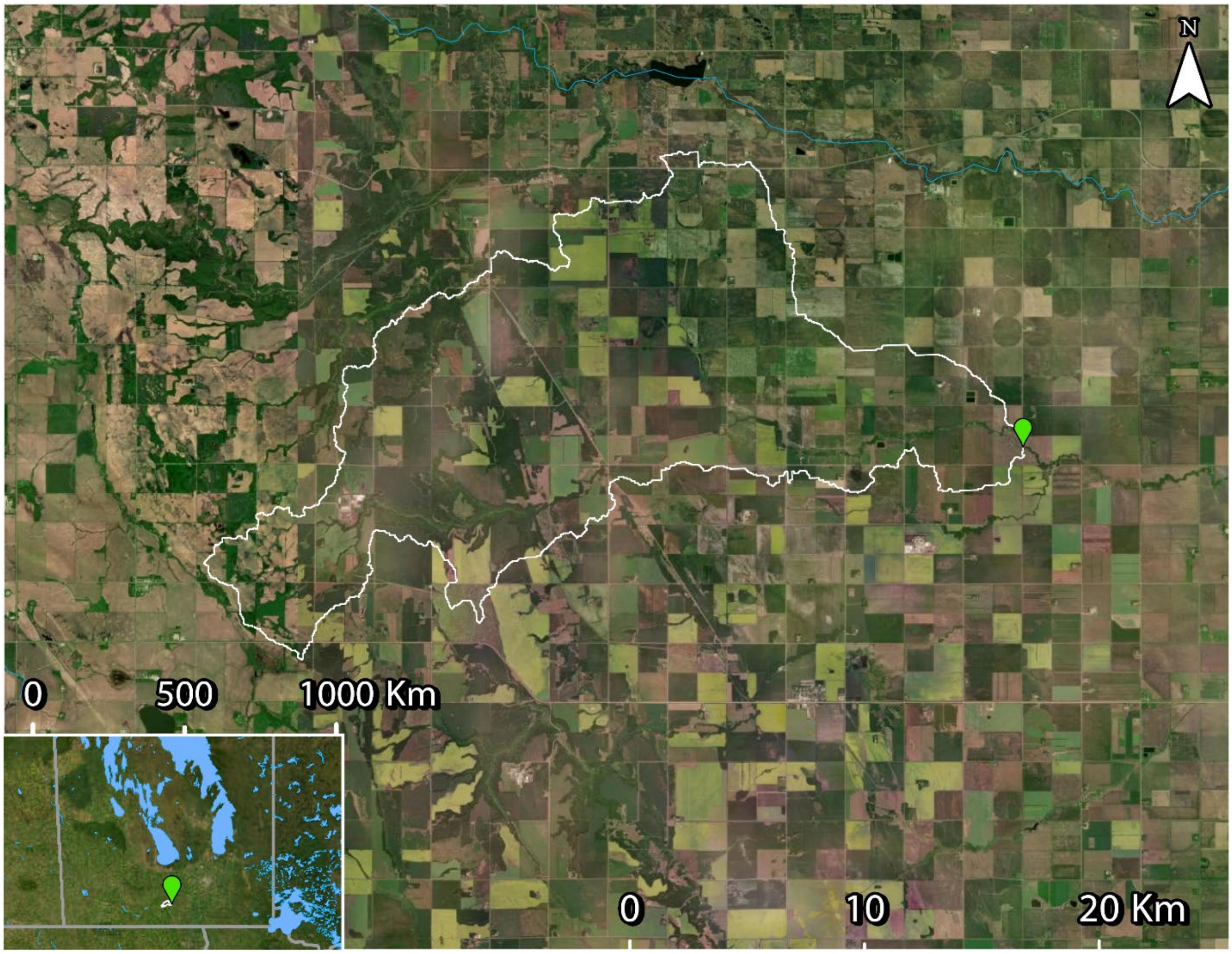


Figure 17: WSC station 05OF018 (green) and drainage area polygon (white - source: AAFC). LWCBMN samples directly at the WSC station.

Morris River near Rosenort

This sampling site is on the Morris River, upstream of Rosenort, MB. The incremental drainage area Morris River near Rosenort contains largely agricultural area. This sampling site is located at Water Survey of Canada station 05OF020, near Rosenort, MB. The sampling effort provided adequate coverage to calculate TP loads and exports.

Table 10: Indices of discharge and phosphorus from the incremental drainage area of Morris River near Rosenort (05OF020). See Supplemental Table 2 for gross calculations.

Incremental drainage area:	1089.63 km^2
Peak discharge:	104.22 $m^3\ s^{-1}$ (2022-04-30)
Peak TP concentration:	0.63 mg/L (2022-04-11)
% of water load in spring:	73.68%
% of TP load in spring:	77.04%
[1]Incremental water load:	0.020 $km^3\ y^{-1}$
[1]Incremental TP load:	26.12 tonnes P y^{-1}
[2]Incremental water export:	17.92 mm y^{-1}
[2]Incremental TP export:	0.24 kg P $ha^{-1}\ y^{-1}$

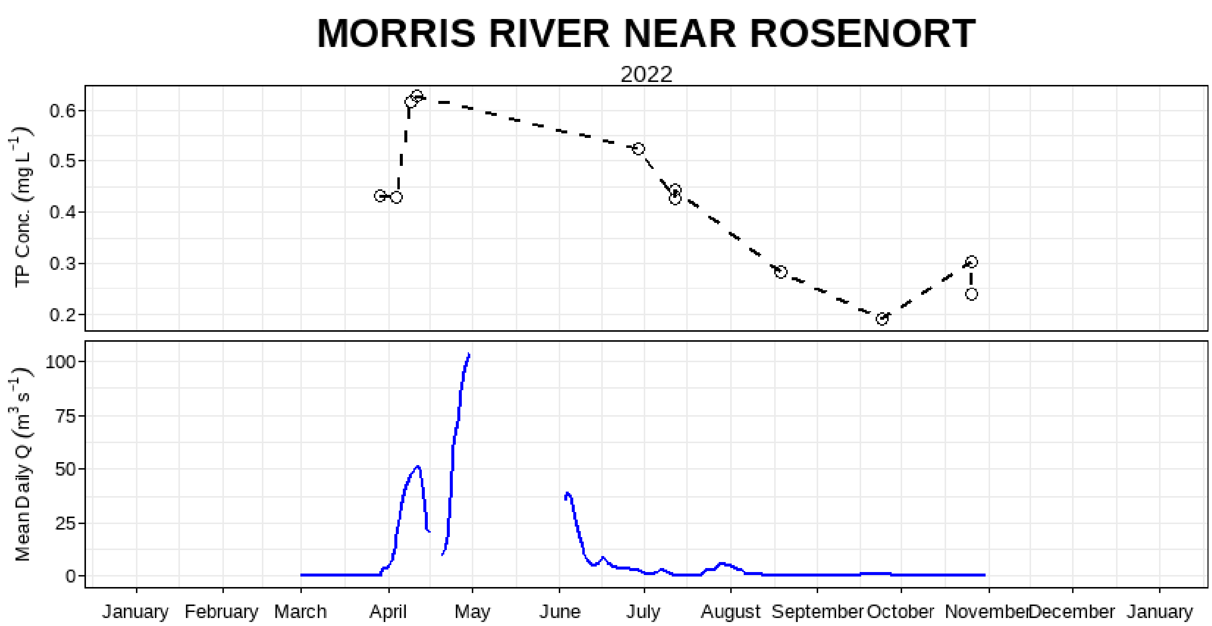


Figure 18: Mean daily discharge ($m^3\ s^{-1}$) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at Morris River near Rosenort (05OF020).

[1] Incremental loads are calculated by subtracting gross "Boyne River near Carman" from "Morris River near Rosenort" values.

[2] Incremental exports are calculated by dividing incremental loads by incremental drainage areas.

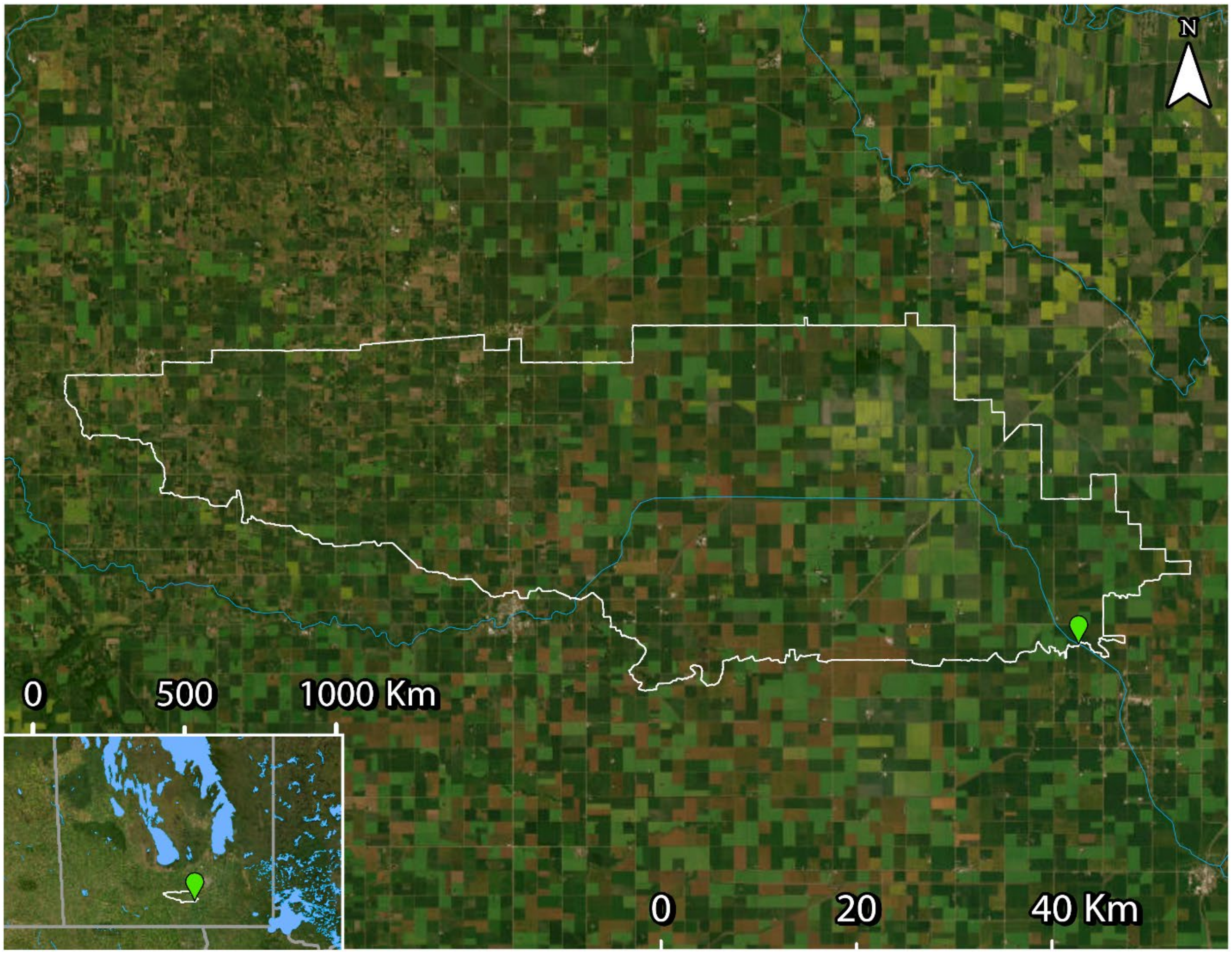


Figure 19: WSC station 05OF020 (green), and incremental drainage area polygon (white - source: WSC). See Supplemental Figure 2 Supplemental Figure 3for upstream drainage areas used to calculate incremental area. LWCBMN samples directly at the WSC station.

Shannon Creek near Morris

Shannon Creek is a part of the Morris River watershed. This sampling site is located on Shannon Creek, upstream of Morris, MB, and just upstream of where Shannon Creek flows into the Morris River. This sampling site is located at Water Survey of Canada station 05OF014, new Sewell, MB. The sampling effort provided adequate coverage to calculate TP loads and exports. However, it should be noted that there is a gap in the real-time flow data in late spring. This is likely due to the extensive flooding which occurred in 2022. As a result, TP loads and exports may be underestimations.

Table 11: Indices of discharge and phosphorus from the gross drainage area of Shannon Creek near Morris (05OF014) in 2022.

Gross drainage area:	635.58 km^2
Peak discharge:	73.34 $m^3 s^{-1}$ (2022-05-02)
Peak TP concentration:	0.92 mg/L (2022-04-09)
% of water load in spring:	93.70%
% of TP load in spring:	97.00%
Water load:	0.083 $km^3 y^{-1}$
TP load:	58.62 tonnes P y^{-1}
Water export:	130.78 mm y^{-1}
TP export:	0.92 kg P $ha^{-1} y^{-1}$

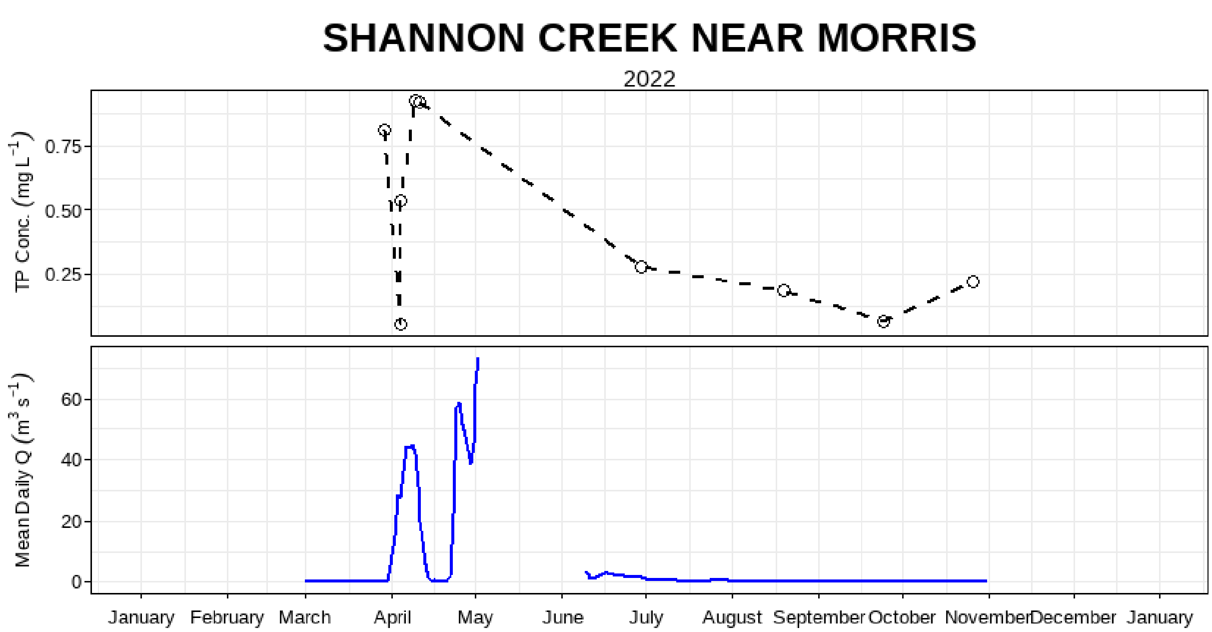


Figure 20: Mean daily discharge ($m^3 s^{-1}$) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at Shannon Creek near Morris (05OF014).

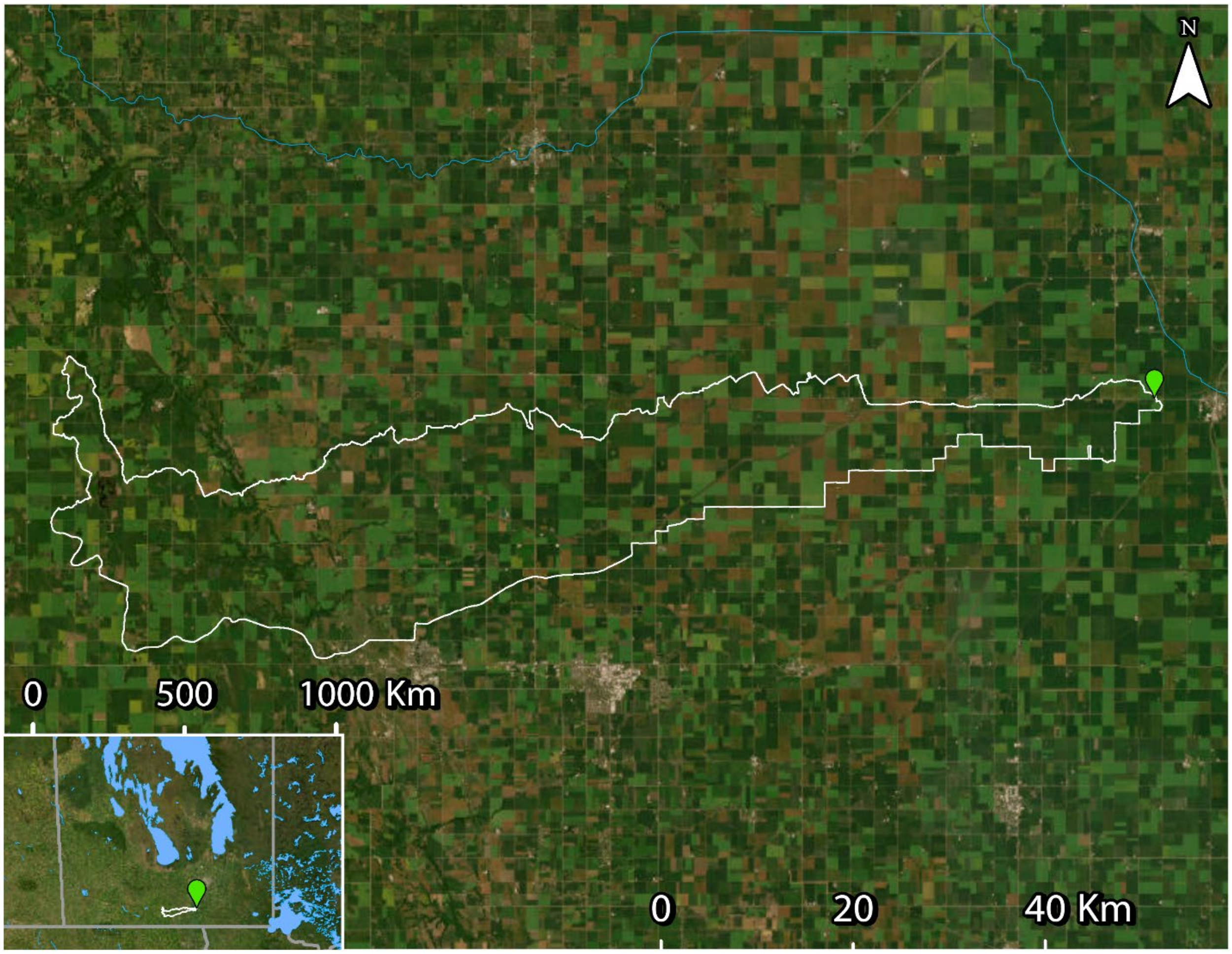


Figure 21: WSC station 05OF014 (green) and drainage area polygon (white – source: AAFC). LWCBMN samples directly at the WSC station.

Little Morris River near Rosenort

This site is on the Little Morris River, upstream of Rosenort and Morris, MB. The sampling site is located at Water Survey of Canada station 05OF024, near Rosenort, MB. The sampling effort provided adequate coverage to calculate TP loads and exports. However, it should be noted that there is a gap in the real-time flow data in late spring. This is likely due to the extensive flooding which occurred in 2022. As a result, TP loads and exports may be underestimations.

Table 12: Indices of discharge and phosphorus from the incremental drainage area of of Little Morris River near Rosenort (05OF024). See Supplemental Table 3Supplemental Table 4 for gross calculations.

Incremental drainage area:	780.44 km^2
Peak discharge:	105.62 $m^3\ s^{-1}$ (2022-04-27)
Peak TP concentration:	0.81 mg/L (2022-04-09)
% of water load in spring:	87.62%
% of TP load in spring:	90.87%
[1]Incremental water load:	0.075 $km^3\ y^{-1}$
[1]Incremental TP load:	30.11 tonnes P y^{-1}
[2]Incremental water export:	96.46 mm y^{-1}
[2]Incremental TP export:	0.39 kg P $ha^{-1}\ y^{-1}$

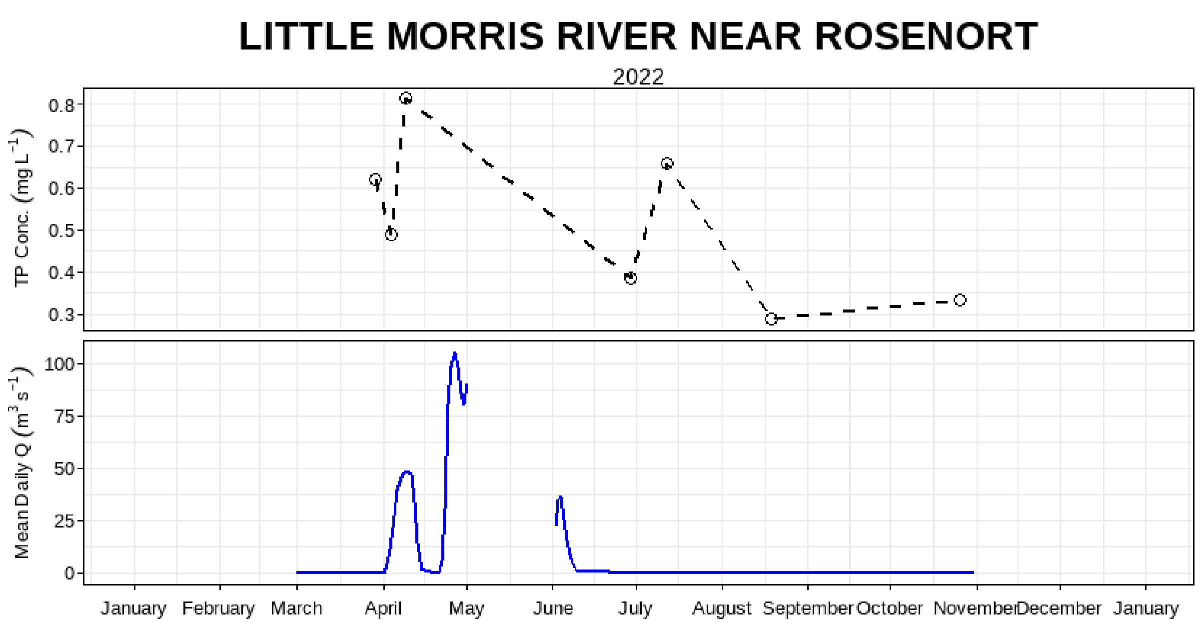


Figure 22: Mean daily discharge ($m^3\ s^{-1}$) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at Little Morris River near Rosenort (05OF024).

[1] Incremental loads are calculated by subtracting gross "South Tobacco Creek near Miami" and "Tobacco Creek near Rosebank" from "Little Morris near Rosenort" values.

[2] Incremental exports are calculated by dividing incremental loads by incremental drainage areas.

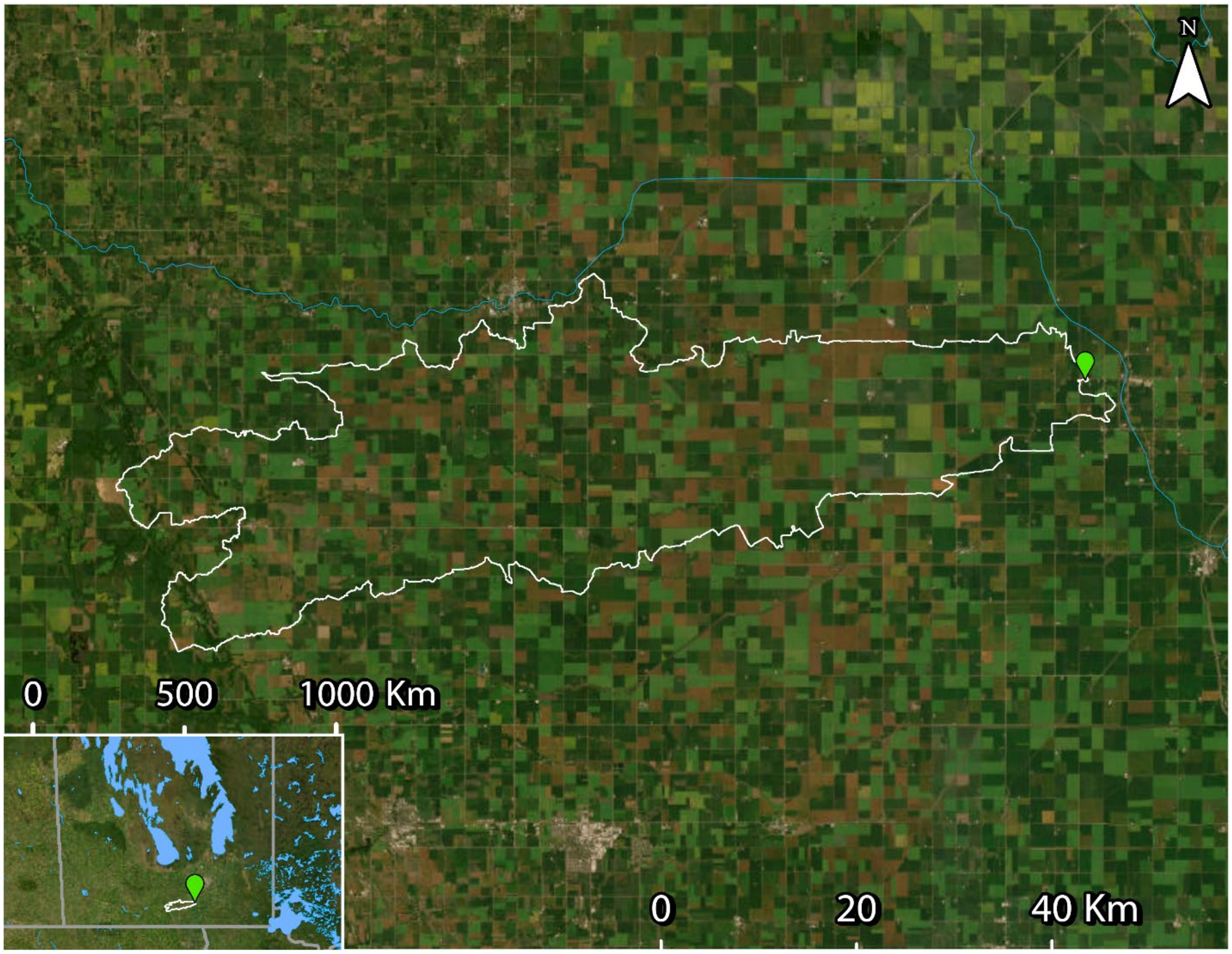


Figure 23: WSC station 05OF024 (green), and incremental drainage area polygon (white - source: WSC). See Supplemental Figure 3 for upstream drainage areas used to calculate incremental area. LWCBMN samples directly at the WSC station.

Assiniboine River near Headingly

The sampling site is located at Water Survey of Canada station 05MJ001. The sampling effort provided adequate coverage to calculate TP loads and exports.

Table 13: Indices of discharge and phosphorus from the incremental drainage area of of Assiniboine River near Headingly (05MJ001). See Supplemental Table 4 for gross calculations.

Incremental drainage area:	11052.37 km^2
Peak discharge:	307.94 $m^3\ s^{-1}$ (2022-06-01)
Peak TP concentration:	1.15 mg/L (2022-05-03)
% of water load in spring:	38.58%
% of TP load in spring:	49.03%
[1]Incremental water load:	-0.082 $km^3\ y^{-1}$
[1]Incremental TP load:	847.86 tonnes P y^{-1}
[2]Incremental water export:	-7.38 mm y^{-1}
[2]Incremental TP export:	0.77 kg P $ha^{-1}\ y^{-1}$

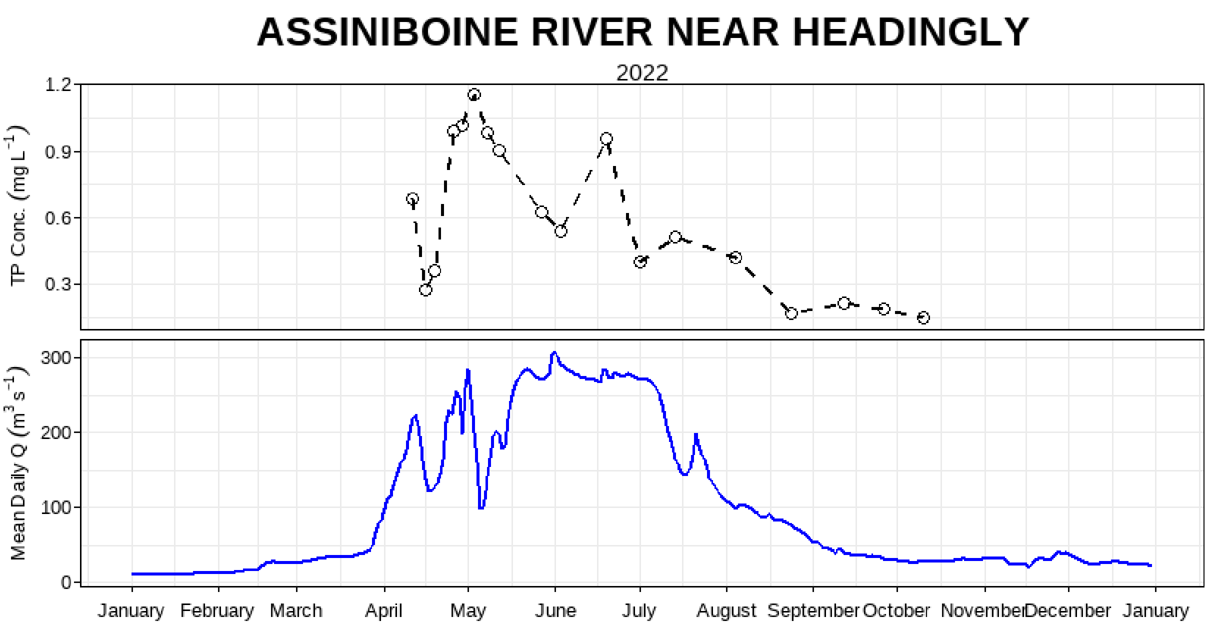


Figure 24: Mean daily discharge ($m^3\ s^{-1}$) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at Assiniboine River near Headingly (05MJ001).

[1] Incremental loads are calculated by subtracting gross "Assiniboine River near Brandon", "Cypress River near Bruxelles", "Little Souris River near Brandon", "Medora Creek near Napinka", "Plum Creek near Souris", "Souris River at Melita", and "Stony Creek near Broomhill" from "Assiniboine River near Headingly" values.

[2] Incremental exports are calculated by dividing incremental loads by incremental drainage areas.

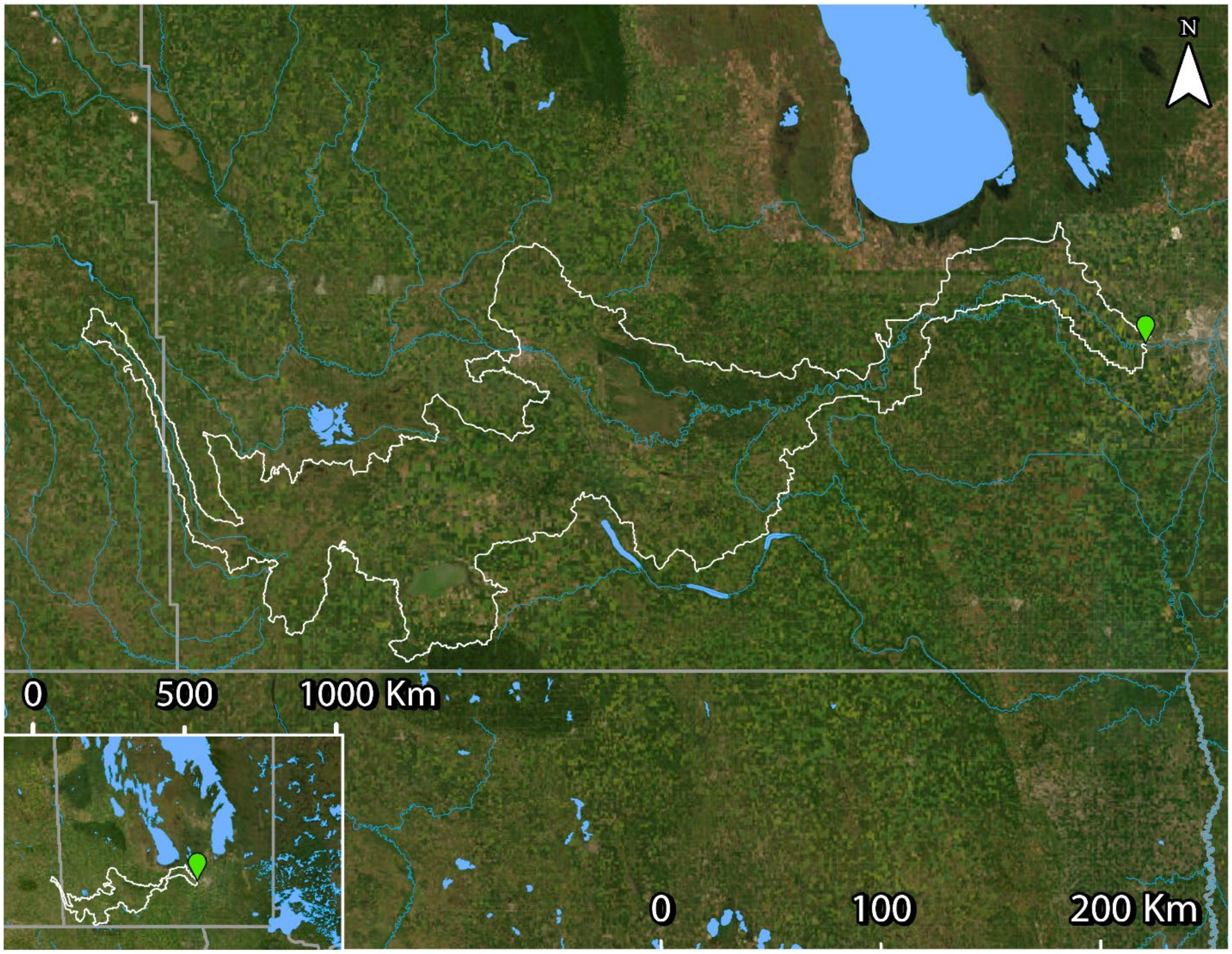


Figure 25: WSC station 05MJ001 (green), and incremental drainage area polygon (white - source: WSC). See Supplemental Figure 4 for upstream drainage areas used to calculate incremental area. LWCBMN samples directly at the WSC station.

Sites without capacity for load/export calculation

La Salle River at Sanford

This downstream reach of the La Salle River is located west of the Red River and flows easterly. The incremental drainage area contains primarily agricultural land (both cropland and livestock). Because the Sanford Dam is between the sampling site and the WSC station, this prevents accurate calculation of load/export.

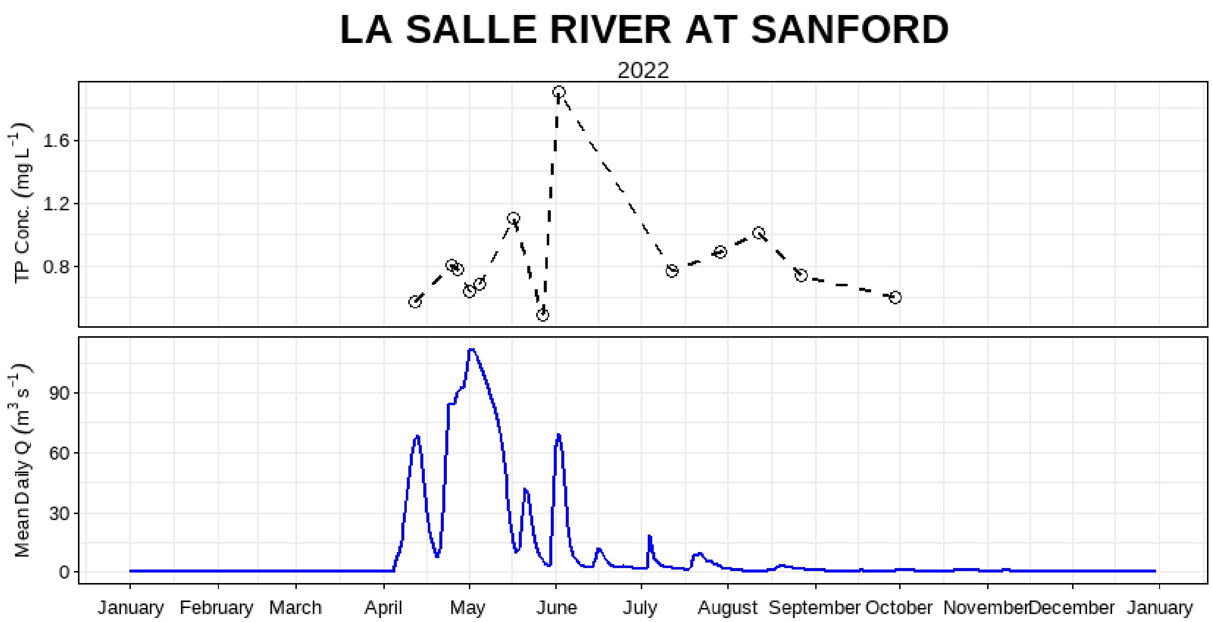


Figure 26: Mean daily discharge (m³ s⁻¹) and total phosphorus concentration (mg L⁻¹) over the 2022 sampling season at La Salle River at Sanford (05OG001).

La Salle River at La Salle

This sampling site is located on the La Salle River in the town of La Salle, Man. The area that drains into this stretch of the La Salle River includes a largely agriculture area and the community of La Salle. This sampling site is located at Water Survey of Canada water level meter 05OG002, in La Salle. We cannot calculate phosphorus loads and exports because flow is not measured.

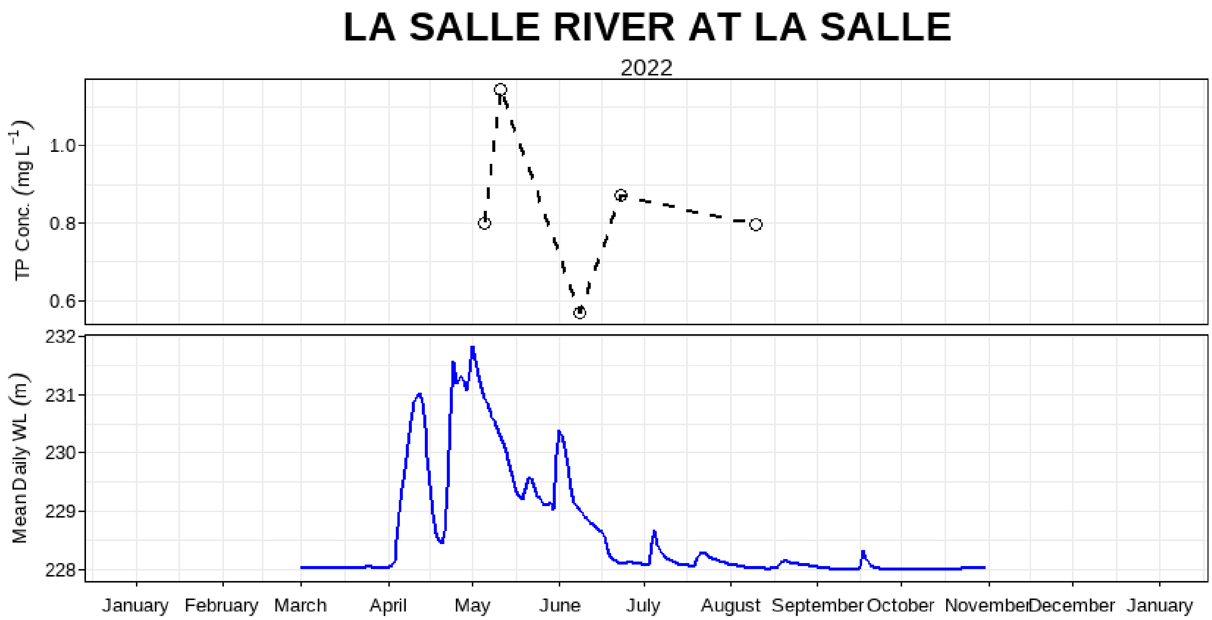


Figure 27: Mean daily water level (m) and total phosphorus concentration (mg L^{-1}) at La Salle River at La Salle (05OG002).

Assiniboine River near Portage La Prairie

This sampling site is located on the Assiniboine River near Portage La Prairie. This sampling site is located at Water Survey of Canada station 05MJ003. Calculating phosphorus loads/exports would be quite inaccurate due to the lack of samples taken after early May, when flow was highest.

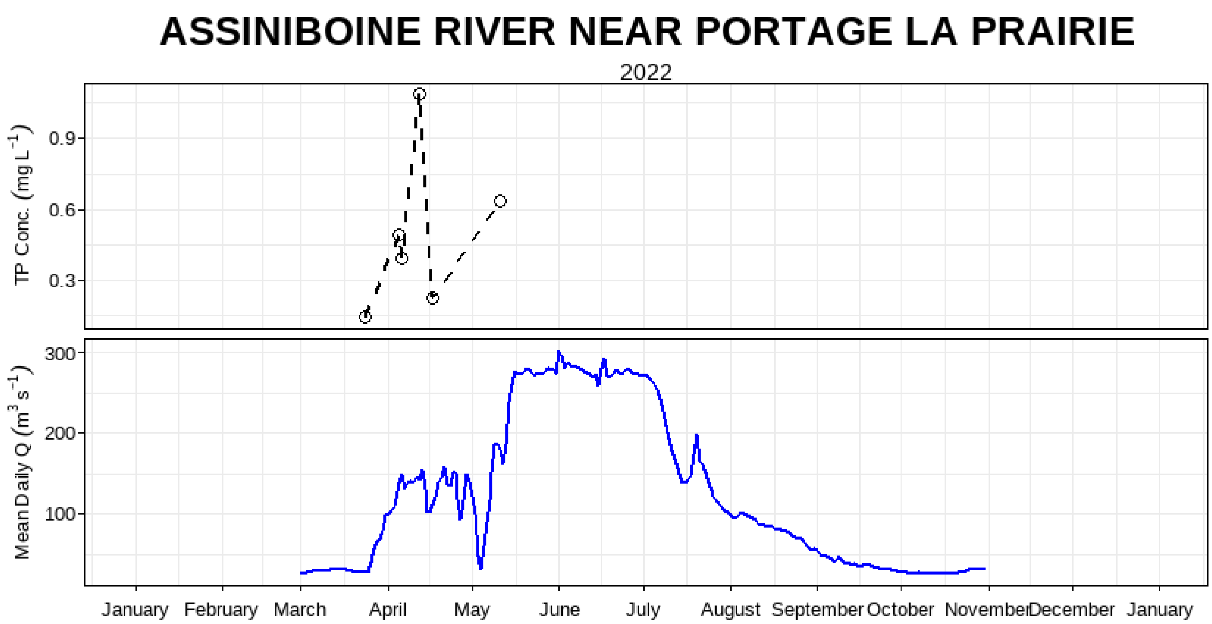


Figure 28: Mean daily discharge (m^3 s^{-1}) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at Assiniboine River near Portage La Prairie (05MJ003).

Portage Diversion near Portage La Prairie

This sampling site is located at Water Survey of Canada station 05LL019. Calculating phosphorus loads/exports was not possible due to the lack of samples.

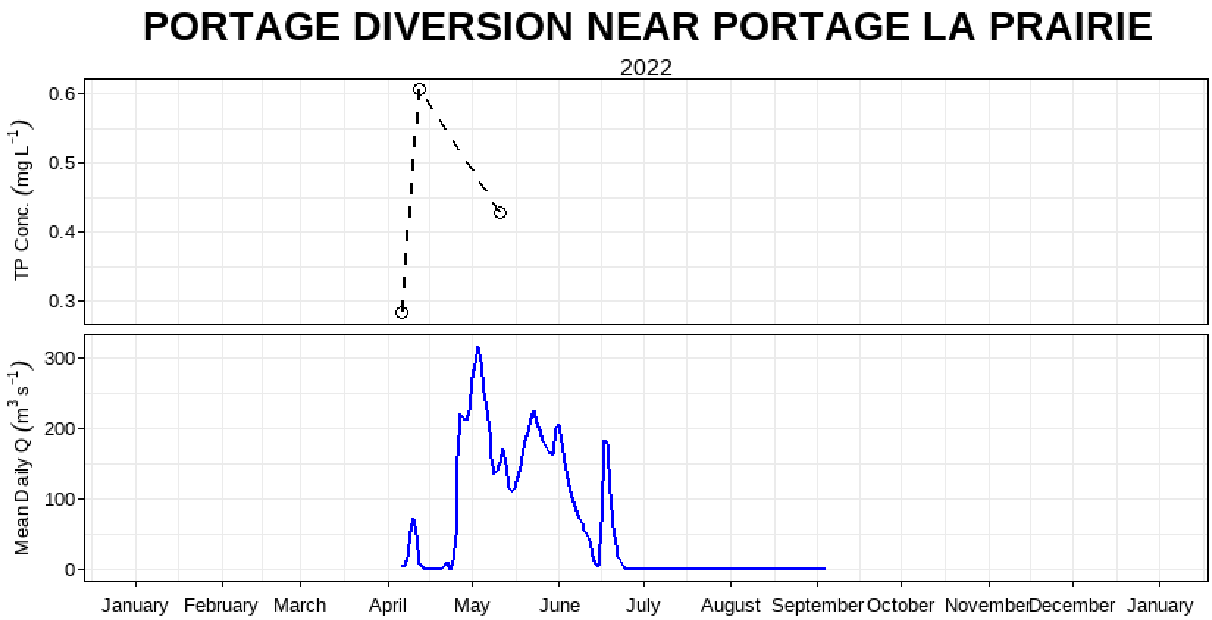


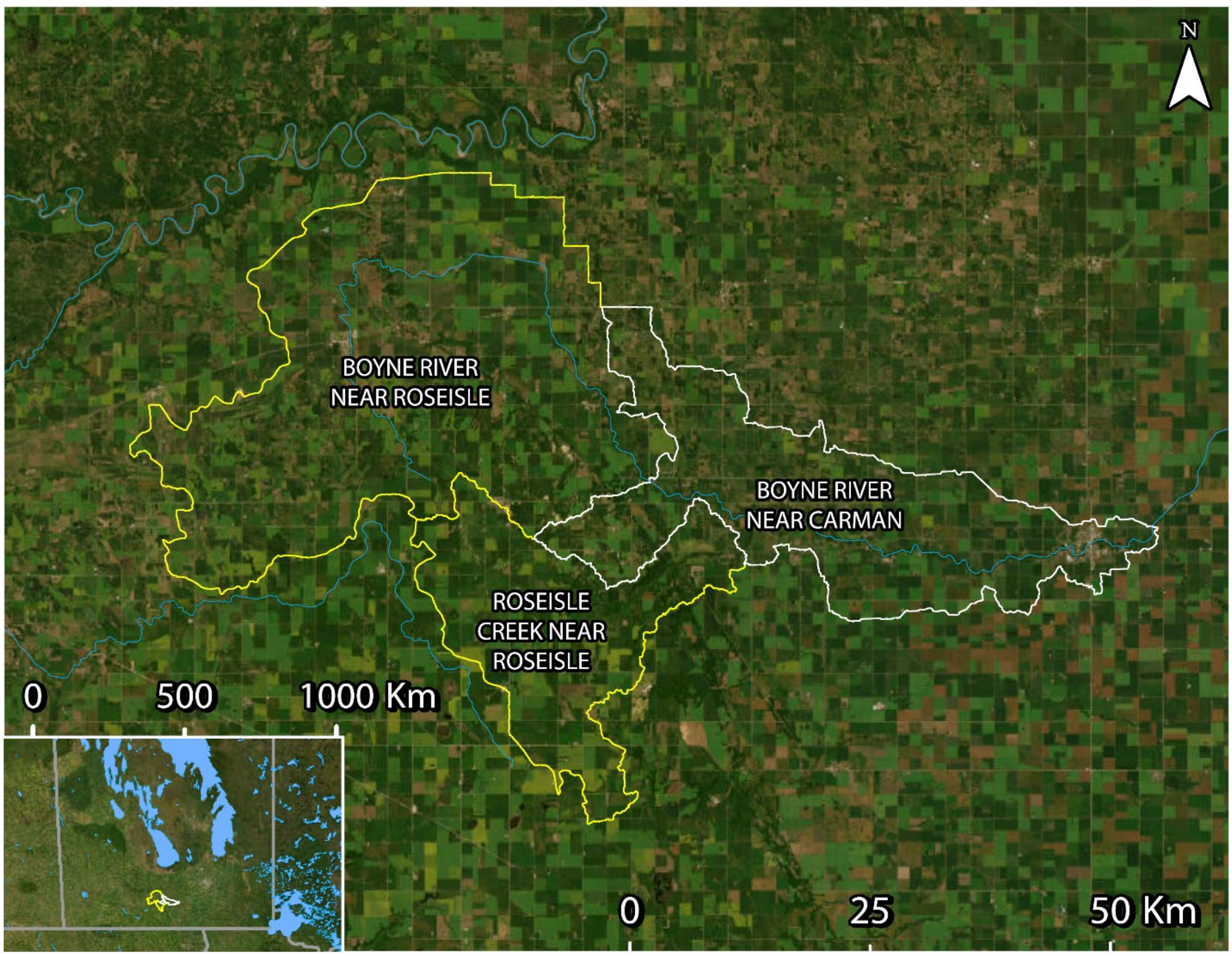
Figure 29: Mean daily discharge (m^3 s^{-1}) and total phosphorus concentration (mg L^{-1}) over the 2022 sampling season at Portage Diversion near Portage La Prairie (05LL019).

Incremental Calculations

Boyne River near Carman

Supplemental Table 1: Indices of discharge and phosphorus from the combined gross drainage area and stream discharge of Boyne River near Carman (05OF003).

Gross drainage area:	1134.51 km^2
Water load:	0.12 km^3 y^{-1}
TP load:	52.24 tonnes P y^{-1}
Water export:	104.45 mm y^{-1}
TP export:	0.46 kg P ha^{-1} y^{-1}

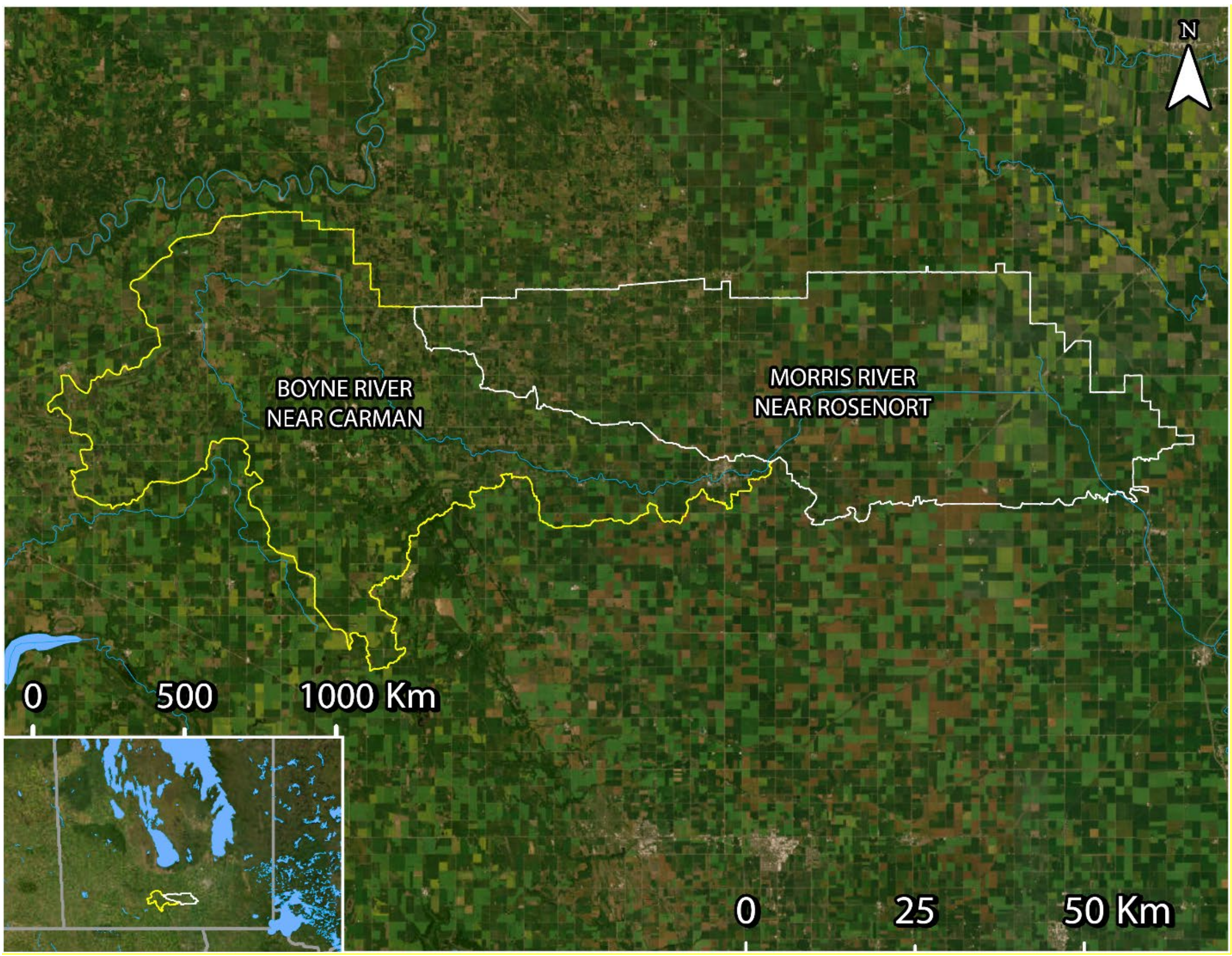


Supplemental Figure 1: Incremental drainage area in white and upstream drainage areas in yellow. Incremental loads are calculated by subtracting gross “Boyne River near Roseisle” and “Roseisle Creek near Roseisle” from “Boyne River near Carman” values.

Morris River near Rosenort

Supplemental Table 2: Indices of discharge and phosphorus from the gross drainage area of Pembina River downstream of Morris River near Rosenort (05OF020) in 2022.

Gross drainage area:	2224.14 km^2
Water load:	0.14 $km^3\ y^{-1}$
TP load:	78.36 tonnes P y^{-1}
Water export:	62.06 mm y^{-1}
TP export:	0.35 kg P $ha^{-1}\ y^{-1}$

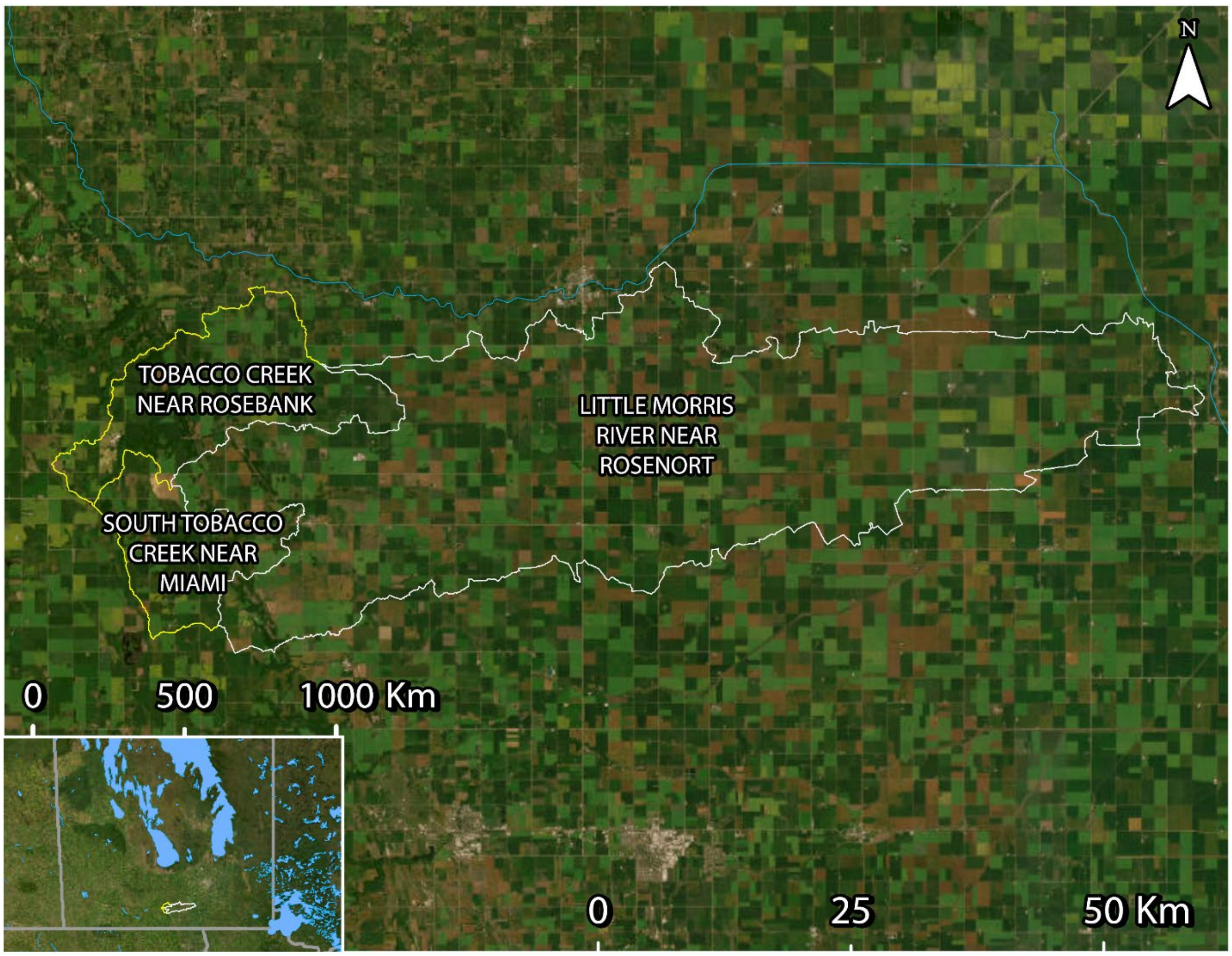


Supplemental Figure 2: Incremental drainage area in white and upstream drainage area in yellow. Incremental loads are calculated by subtracting gross "Boyne River near Carman" from "Morris River near Rosenort" values.

Little Morris River near Rosenort

Supplemental Table 3: Indices of discharge and phosphorus from the gross drainage area of Little Morris River near Rosenort (05OF024) in 2022.

Gross drainage area:	986.24 km^2
Water load:	0.12 $km^3\ y^{-1}$
TP load:	80.46 tonnes P y^{-1}
Water export:	117.47 mm y^{-1}
TP export:	0.82 kg P $ha^{-1}\ y^{-1}$

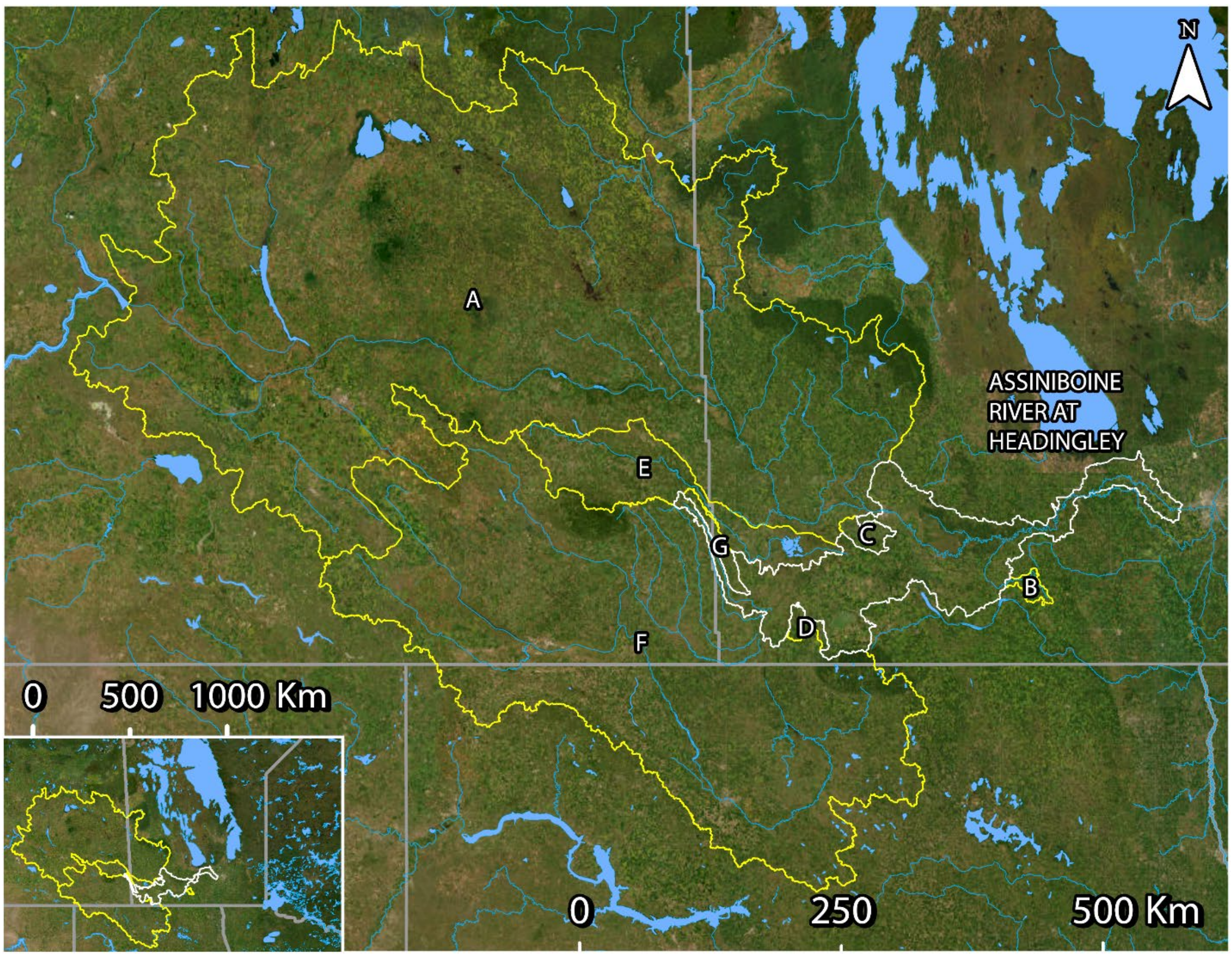


Supplemental Figure 3: Incremental drainage area in white and upstream drainage area in yellow. Incremental loads are calculated by subtracting gross "South Tobacco Creek near Miami" and "Tobacco Creek near Rosebank" from "Little Morris near Rosenort" values.

Assiniboine River near Headingly

Supplemental Table 4: Indices of discharge and phosphorus from the gross drainage area of Assiniboine River near Headingly (05MJ001) in 2022.

Gross drainage area:	161455 km^2
Water load:	3.03 $km^3\ y^{-1}$
TP load:	1798.99 tonnes P y^{-1}
Water export:	18.74 mm y^{-1}
TP export:	0.11 kg P $ha^{-1}\ y^{-1}$



Supplemental Figure 4: Incremental drainage area in white and upstream drainage areas in yellow. Incremental loads are calculated by subtracting gross "Assiniboine River near Brandon"[1] (A), "Cypress River near Bruxelles"[2] (B), "Little Souris River near Brandon"[2] (C), "Medora Creek near Napinka"[3] (D), "Plum Creek near Souris"[3] (E), "Souris River at Melita"[3] (F), and "Stony Creek near Broomhill"[3] (G), from "Assiniboine River near Headingly" values.

[1] See 2022 LWCBMN Assiniboine West report for data from this site.

[2] See 2022 LWCBMN Central Assiniboine report for data from this site.

[3] See 2022 LWCBMN Souris River report for data from this site.

Map Sources

Drainage area polygons

Primarily, and whenever possible, drainage area polygons were taken from the Water Survey of Canada's (WSC) National Hydrometric Network Basin Polygons. Released on July 15, 2022, this prerelease version of the dataset contains drainage area polygons for over 7300 of the 7896 active and discontinued WSC stations. According to WSC, this dataset will continue to be updated as new polygons are added. For our analysis, we used drainage areas from this dataset.

Link: https://catalogue.ec.gc.ca/geonetwork/srv/eng/catalog.search#/metadata/0c121878-ac23-46f5-95df-eb9960753375

Secondarily, when no WSC drainage area polygons were available, or when it was necessary to enable accurate incremental calculations, we used drainage area polygons from the Total Gross Drainage Areas of the Agriculture and Agri-Food Canada (AAFC)'s Watersheds Project – 2013

Link: https://open.canada.ca/data/en/dataset/67c8352d-d362-43dc-9255-21e2b0cf466c

Due to the required use of drainage area polygons from two different datasets, some polygons may slightly overlap. Hotspot maps, as a result, have a few instances where a drainage area is visually cut off. However, most of these instances are very minor, and we display all watersheds in their full extent on each sampling site's individual section.

Map layers

Satellite imagery used in all maps is from the World Imagery map layer (Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community). World Imagery provides one meter or better satellite and aerial imagery in many parts of the world and lower resolution satellite imagery worldwide.

Lake and river map data used in all maps is from North America Environmental Atlas (Lakes, Rivers). The North American Environmental Atlas – Lakes & Rivers datasets display area hydrographic features (Lakes: major lakes and reservoirs; Rivers: major rivers, streams, and canals) of North America at a reference spatial scale of 1:1,000,000. Credits: Commission for Environmental Cooperation (CEC). 2023. "North American Atlas – Lakes and Rivers". Natural Resources Canada (NRCan), Instituto Nacional de Estadística y Geografía (INEGI), Comisión Nacional del Agua (CONAGUA), U.S. Geological Survey (USGS). Ed. 3.0, Vector digital data [1:1,000,000].

The **Lake Winnipeg Community-Based Monitoring Network** (LWCBMN) is a collaborative, long-term phosphorus monitoring program designed to identify localized phosphorus hotspots where action is required to improve Lake Winnipeg water quality. LWCBMN mobilizes citizen volunteers and watershed partners to collect water samples across Manitoba, generating robust water-quality data that is useful to community practitioners, academic researchers, government scientists and policy-makers alike. Focusing research, resources and action in phosphorus hotspots is necessary to reduce phosphorus loading to Lake Winnipeg.

LWCBMN is delivered in partnership with Manitoba's watershed districts, LWF's science advisors, volunteer citizen scientists and Dr. Nora Casson's laboratory at the University of Winnipeg. Thank you to all who make this network possible!

The **Lake Winnipeg Foundation** (LWF) advocates for change and coordinates action to improve the health of Lake Winnipeg. Combining the commitment of our grassroots membership and the expertise of our science advisors, LWF is nationally recognized for our unique capacity to link science and action. Our goal is to ensure policy and practices informed by evidence are implemented and enforced.

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